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Pertinent advertisements will be accepted from reputable firms. Correspondence in relation thereto should be addressed to the secretary-treasurer.

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Revenue accruing to the Society from subscriptions will be wholly utilized for the support and enlargement of the Journal.

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A SYMPOSIUM

ON A NATIONAL MALARIA PROGRAM

FOR THE CONTROL OF MALARIA

Presented at the Joint Session of the National Malaria Society and the American Society of Tropical Medicine, meeting with the Southern Medical Association, at Cincinnati, Ohio, November 16-18, 1943. (Session of November 18th, 1943) Under the Auspices of the Southern Medical Association.

AMERICAN MOBILIZATION FOR THE CONQUEST OF MALARIA IN THE UNITED STATES

Introduction To A Symposium On Our National Program for the Control of Malaria

By

Brigadier General James Stevens Simmons, U. S. Army
Chief, Preventive Medicine Service, Office of The Surgeon General, U. S. Army
President, National Malaria Society.

Fellow members of the National Malaria Society, guest speakers, ladies and gentlemen!

I wish to thank you for the honor which you have shown me and the Medical Department of the Army, in selecting me as president of this distinguished organization which, for so many years, has been dedicated to the control of the world's greatest scourage —malaria. It has been customary in past years for the individual elected to this office to start the annual meeting with a presidential address. With your permission, I wish to deviate from this custom during the present meeting in order to devote more of our limited time to the grave problem which war-time malaria now presents to the nation and to our Society. Thus, the usual formal address will be omitted and instead I wish to open this Symposium on our National Program for the Control of Malaria with a brief introductory statement indicating the new malaria hazards which the war has created for our country;—the various health agencies which are working together to protect the nation both now and after the war—against this menace to our civilization. Also, I wish to mention and to suggest a new goal for the future—namely the conquest of malaria in the United States.

The present world war has imposed new disease hazards and problems in preventive medicine on all the peoples of the globe. This applies not only to the inhabitants of war-torn regions but to the citizens of the United States, and these problems must be met and solved in order to ensure our continued existence as a strong, free nation. One of the most important of America's war-time disease problems is that of protecting the people of the United States against the new threat of invasion by foreign malaria.

The malarial fevers, especially the benign tertian infections, have always existed in this country, being most prevalent in the South, and from the early days of colonial exploration and settlement until a few decades ago, they were one of the most important causes of disability and death. Even today malaria is still prevalent

in many Southern states. However, considering the country as a whole the incidence of the disease has decreased progressively for many years, and in many areas where formerly it was feared, malaria no longer exists.

This decrease in malaria in the civilian population has been paralleled by the incidence records for United States troops stationed in this country. During the 100 years prior to the discovery of the mosquito transmission of malaria at the end of the last century, our Army malaria admission rates were extremely high, varying between 100 and 1000 per 1000 per annum. Since 1900 the rates have declined progressively, reaching a low of 1.7 in 1940.

Thus when we entered the present war we still had an important malaria problem in this country. However, the disease had been eliminated among the civilians of many regions and decreased in others, and its prevalence among our troops at home was insignificant. We had lived with our domestic malaria for a century and a half—we had fought it with considerable success—and as we had hopes of its eventual control, we no longer feared it.

However, the war has brought with it various new conditions which restore malaria to its former position as a potential national menace. These conditions include, first, the increased exposure of our Armed Forces to infection abroad; second, the introduction of foreign strains of plasmodia into this country by the return of infected personnel from overseas, and third, the possibility of introducing new mosquito vectors of malaria from abroad. All of these hazards are real, and if we are to guard against them adequately, it is essential that all of our efforts against this disease be welded into a coordinated National Control Program. It is therefore important that we take stock of all of the control work being done in the United States at the present time in order to weigh it and consider its adequacy.

The present war-time Army program was started early in 1940 when it seemed likely that the United States would be forced into the War, and since then it has been rapidly expanded to meet new military situations at home and abroad. As a part of this program, the Army requested the U. S. Public Health Service to undertake its present nation-wide program of extra-military mosquito control which has supplemented the work done by the Army inside the military reservations. This has been carried out through state and local health agencies. The Navy, too, has had its malaria problems and its control program. These Federal medical agencies have been assisted by advisory committees of the Division of Medical Sciences of the National Research Council, and the numerous investigations required by them have been activated

through the Committee on Medical Research of the Office of Scientific Research and Development. The Bureau of Entomology and Plant Quarantine of the Department of Agriculture has helped in many ways, including the investigation and production of new insecticides and repellents. Malariologists and entomologists in various scientific institutions have sought better drugs with which to prevent and treat malaria. Still other agencies, including the Pan American Sanitary Bureau, the International Health Division of The Rockefeller Foundation, and the Health Division of the Office of the Coordinator of Inter-American Affairs, have contributed in various ways to the control of malaria in the Western Hemisphere. Both military and civilian agencies have been actively concerned with increasing the nation's facilities for training in tropical medicine and malaria control.

Because of the unusual difficulties experienced in the protection of military personnel against malaria under combat conditions in certain highly endemic areas abroad, it has been inevitable that a number of our men have become infected, and that a great many of these infected persons have been brought back to the United States within recent months. As was anticipated, this has made it necessary to take special precautions not only to effect a cure for these chronic infections, but to prevent the spread of infection from such individuals to other persons at home. The Army is meeting this situation by every means available, including the intensification of mosquito control around the hospitals where chronic malaria patients are concentrated. For several years the threat of invasion by new insect vectors from abroad has been recognized and the Armed Forces have had strict regulations aimed at the prevention of this possibility. These regulations are now being further strengthened by an Interdepartmental Quarantine Commission which is headed by Dr. Dunnahoo of the U. S. Public Health Service, Chief Quarantine Officer for the United States, and includes members from the Army and Navy.

This Symposium has been planned in order that we may review briefly the malaria control policies and activities of all these and other great national health organizations including the Tennessee Valley Authority about which Dr. Bishop talked yesterday. It is hoped that such a review will help us to visualize more clearly our total national effort and our facilities. This should enable us to strengthen the program where necessary in order to protect the United States against both the war-time and post war-time hazards of malaria.

The ultimate goal of this program should be the elimination of malaria as a problem in this country. In order to accomplish

this we must plan now to continue our present effective control organizations after the war and to mold these into a united team, in order that through their combined efforts we may complete the job which started with the work of Gorgas and his associates in Panama, and wipe malaria out of the United States.

To summarize, gentlemen, you have for your consideration today, the integral parts of a National Program for the Control of Malaria. It is a huge task that confronts us, and some will say an impossible one. With the latter I cannot agree. We are now armed with exact knowledge about malaria. We know its cause, its local vectors, and we are provided with proven methods for its control under the conditions which exist in the United States. Thus we have the necessary knowledge and we also have the intelligence to apply this knowledge. All that is needed is the proper coordination of our knowledge and facilities for an effective attack.

It is my belief, which is shared I know by many of you, that it is possible to make the United States a malaria-free country, one which will exemplify to other countries what can be accomplished in the eradication of one of the world's most serious diseases.

From the excellent papers presented at this meeting it is evident the country's malaria control forces have been effectually mobilized to meet the war time hazards of malaria at home and abroad. These forces are now proceeding at full speed and with the spiritual and financial support of the entire country.

When the war with the Axis is won we will demobilize our troops and there will be a tendency to discontinue the financial support of all war time activities. We must not let this happen to our National Program for Malaria Control. We must not demobilize until we have defeated our enemies. It is to be expected that the National Malaria Society and the American Society of Tropical Medicine will continue their leadership in this important mission and see that it is carried to a successful conclusion.

THE MALARIA CONTROL PROGRAM OF THE ARMY

O. R. McCoy, Major, M. C.
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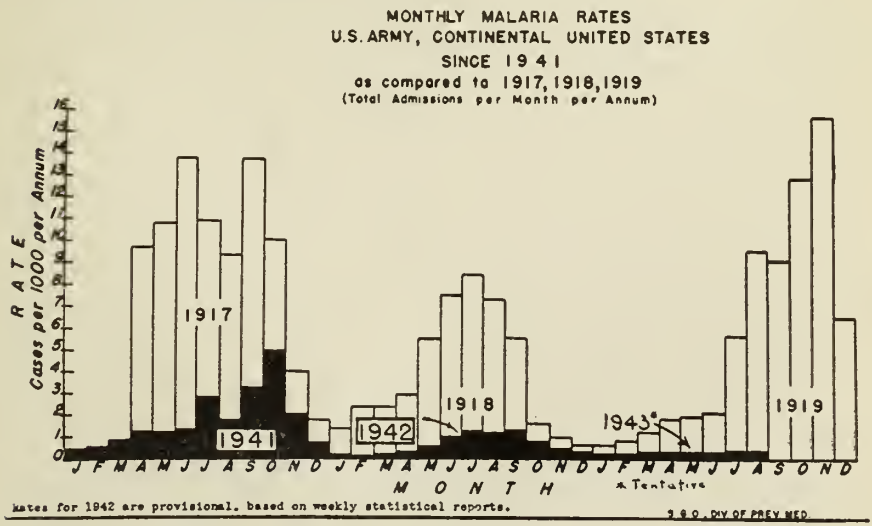
The problem of malaria control in the Army may be divided into two phases. One phase has to do with the protection of soldiers at training camps and fixed and semipermanent bases The other deals with the protection of troops in forward areas and in combat. With the progress of the war and the extension of combat activities in tropical areas, the latter phase of the problem has become increasingly important. A brief review will be given of the program which has evolved in the Army to meet these phases of the malaria problem as they have developed.

During the period of rearmament before we entered the war, large numbers of soldiers were assembled for training in our southern states. It was early planned by the Surgeon General that the Army would conduct mosquito control operations within the boundaries of military reservations. In addition, it was arranged for the United States Public Health Service to institute control measures in a mile-wide zone surrounding the reservations, when necessary. The early planning and effective carrying out of this program has kept malaria among troops in the continental United States at a satisfactorily low level. A comparison of rates during the present war with those during the first World War affords a good measure of the degree of control which has been attained.



Rates for 1942 are provisional, based on weekly statistical reports.

S.G.O., DIV. OF PREV. MED.

A malaria problem for the Army outside this country began with the development of our fortifications in the Caribbean area and the movement of garrisons to these bases. A special health service, organized by the Surgeon General, planned for malaria control during the construction period. As a result, malaria, although a constant threat, has not become a serious problem at these installations.

The full impact of malaria upon our military forces was not experienced until troops were moved into fighting zones in Asia, the South and Southwest Pacific, and soon afterward, in North Africa. To meet the need for specially trained personnel required for effective control, the War Department authorized the establishment of a Special Malaria Control Organization. This organization includes medical officers specially trained as malariologists, and survey and control units headed by parasitologists, medical entomologists, and sanitary engineers. In addition to officers, each unit contains eleven enlisted men. The assembly and technical training of specialized personnel in sufficient numbers is in itself a problem. The cooperation of the Tennessee Valley Authority, The Rockefeller Foundation, the Florida State Board of Health, and the Pan American Highway Commission has been obtained in meeting this need. An Army School of Malariology is now being established in Panama to meet future needs.

Malariologists, survey and control units have been sent to all tropical theaters of operation. The units are fully supplied and equipped before leaving this country. They serve under the command of the theater surgeon and their general function is to plan, supervise, and help carry out measures for malaria control. They provide technical advice to unit commanders and assist them in developing malaria discipline among their troops. The carrying out of extensive filling, draining and spraying operations is accomplished by the use of Engineer troops and by the employment of native labor, when available.

At fixed and semipermanent bases malaria control has been chiefly a matter of applying standard antimosquito measures adjusted to meet local conditions. The provision of trained personnel together with sufficient supplies and equipment is proving adequate to meet this phase of the Army's malaria problem, after local handicaps of terrain and transportation have been overcome.

In forward areas, however, particularly under combat conditions, protection from malaria presents a different problem from that at base installations. Personal measures of protection supplant the standard antimosquito methods which ordinarily are associated with malaria control. Accordingly, soldiers must be trained in applying

the individual measures of protection which they themselves must employ—the proper use of such things as protective clothing, repellents, sleeping nets, and aerosol sprays. A War Department directive provides for training in malaria control for everyone in the Army. An accompanying circular outlines the training to be given. Provision is also made that every Army unit equivalent in size to a company must have an antimalaria detail. The duties of this detail are to check the malaria discipline of the unit and to carry out the simple measures of mosquito control within the area occupied by the unit.

Strengthening the degree of malaria discipline in the Army is considered to be the most important measure that can bring about a substantial reduction in the amount of malaria among combat troops. Accordingly, a concerted effort is being made to see that every man in the Army, from commanders down, is fully informed regarding the military importance of malaria, and that he has an understanding of the various means of preventing the disease. Men must be convinced that they should be as careful to protect themselves from the malaria mosquito as from the enemy. A program of this scope requires publicity. The cooperation of the Special Service Division has been secured to prepare cartoon movie shorts and posters. In various ways Special Service will conduct an antimalaria publicity campaign, along with their regular duties of providing entertainment and recreation for the troops. Good malaria discipline requires not only understanding but also good basic morale.

Another aspect of the malaria control program of the Army deals with the prevention of the spread of malaria by infected soldiers returned from overseas. Since anopheline mosquitoes are widespread throughout the United States, it is not practicable to attempt to declare areas where anopheline mosquitoes are present as out of bounds to returned troops. The program of mosquito control conducted by the Army and by the United States Public Health Service in and around military camps and general hospitals is considered the most feasible safeguard to prevent spread of malaria to civilians. This program was originally instituted to prevent soldiers from acquiring malaria from civilians. However, it also works just as well the other way around. The Army is fully aware of its responsibilities in helping prevent the spread of malaria by returning military personnel, and is maintaining close cooperation with the United States Public Health Service in dealing with this problem.

It is evident from the foregoing summary that a wide variety of measures is included in the Army's program to combat malaria.

The possibility of improvement of present methods and the development of new measures has not been neglected. Early in the present emergency the Surgeon General, through the National Research Council, promoted a research program to investigate new drugs, insecticides and repellents. Close liaison is maintained with the many agencies and groups that are working on these problems. The Army conducts field tests of new materials that show promise. Since the war started important advances have been made. Others are on the horizon. The prospects are good that losses and ineffectiveness caused by malaria will be materially reduced.

THE MALARIA CONTROL PROGRAM OF THE NAVY

By

Omar J. Brown,
Commander (MC), U. S. N.

To the Navy, malaria cannot be considered less than a world menace, to be combated on a world scale. Logically, the underlying assumption must be that prevention is economically and militarily more sound and cheaper than cure. It is of little advantage to train men for combat duty only to have them spend their fighting time hospitalized with chills and fever. Our control efforts must encompass a wide range and be fitted to circumstances which vary from place to place, depending upon local conditions, upon the military mission of the forces engaged and the tactical conditions presented.

The total amount of malaria in the world today is unknown, but it has been estimated that in normal times from 1/4 to 1/3 of the world's population suffer with this disease each year and Osler has stated that by those who know the most about disease, "malaria would probably be voted the greatest single destroyer of the human race."

Malaria is more or less world-wide in its distribution but shows a considerable variation in its endemicity. The United States fortunately lies in an area of relatively low endemicity and, except for rare localized incidents in the past, has been spared the misfortunes accompanying severe epidemics. Until malaria struck our troops in epidemic proportions and suddenly focused our attention in this direction, it was generally considered lightly by most persons connected with the medical profession, and with considerable indifference by the general public.

With the exception of Naval engagements and the Aleutian campaign, the present war is being waged in some of the most malarious areas in the world. It was present at Bataan, greeted us in the South and Southwest Pacific, immobilized the British in their recent abortive campaign in Burma and accompanied both Montgomery and Rommel during their stay in Africa. It was awaiting our troops upon their entry into Italy, and irrespective of our final route to Berlin, whether through the Balkans, up the Danube, from the West, or from the North, it will be a real or a potential hazard. Due to Allied experience in the last war, the dangers of the Southern approach are generally well recognized, but we cannot disregard the potential hazard of an invasion from the North or by the channel, if that should occur. In the Summer of 1809, the

British undertook a substantial ship to shore operation in Flanders with a force of some 70,000 men. Within a little over two months, malaria had decimated this force, the campaign was over and an inglorious withdrawal had taken place. A tabulation of results following this effort showed better than 30,000 casualties by the mosquito, with between 3,000-4,000 deaths; casualties by enemy action two hundred forty eight (248). And if we but look at the malaria map it is strikingly apparent that practically all likely roads leading to Tokyo will be well guarded by the Anophelines.

With the development of new methods of offense and defense, styles of warfare change and because of these developments, today we find that practically all military operations have been combined Army and Navy undertakings. Except on the high seas, where you find one service you find the other also. And since malaria is no more a respector of services than it is of nationals, it is obvious that the malaria control programs in the Army and Navy should have been developed jointly. This has been the case. The control programs of Army and Navy have been worked out in close cooperation even to the inclusion of comparable equipment. And in some areas, notably the South and Southwest Pacific, except administratively, service distinctions have been lost. Not infrequently we find Naval personnel working under Army supervision or Naval entomologists directing the activities of an Army unit.

The technics of modern warfare, as they have been taught, rather sharply demarcate the tasks normally applying to the Navy and Marine Corps from those applying to the Army. Essentially these call for the Navy to "soften" the beach, the Marines to spearhead the attack and establish a beach head, the Army coming in later to hold and consolidate the initial gains. With the present war being fought on so many fronts, it has been impossible to follow these theoretical concepts. Today we find Army forces making initial landings; the Marines conducting holding operations and blue jackets *ashore* establishing, maintaining and operating supply bases, airfields and hospitals.

As has been indicated, the Naval malaria control efforts are comparable to those of the Army in all respects. For the protection of our home troops assigned duty at camps located in endemic areas, comprehensive control programs have been developed and undertaken. Due to the shortage of medical and technical personnel trained in the problems of malaria, we too have found it necessary to undertake rather extensive educational work. Special courses of instruction for the officers and enlisted personnel who make up our control teams are given at the Naval Medical School, at the

malaria control headquarters in the South Pacific, and some of our personnel have taken the course in practical malariology given at the University of Brisbane. Facilities in the United States and overseas have been utilized in giving necessary practical field work. Educational programs having for their purpose the indoctrination of line personnel with the importance of malaria and the methods available for its control have been developed and carried out under the direction of Unit Commanders with the cooperation and assistance of specially trained malaria control groups. Each Construction Battalion has been organized so as to include a sanitary section of 110 men completely equipped with necessary hand tools, sprayers, dynamite and heavy machinery for the purpose of carrying out necessary environmental sanitation under the direction of trained personnel.

But since as basically taught there is a fundamental difference in the employment of Naval and Marine personnel, this difference resulted in a modification of the Navy Control team as compared to that of the Army. With the exception of our teams serving with Marine Divisions and a few teams at larger established overseas bases, which are comparable to the survey units of the Army, our units are small, highly mobile and were organized with the idea that they would move forward immediately back of the assault troops to undertake direction of the early and more or less temporary control measures. When local conditions become somewhat stabilized the work of these units is augumented and supplemented by the Sanitary Section of the Construction Battalion, which is more or less comparable to the control unit of the Army.

The return of individuals from highly endemic malarious area as casualties or otherwise presents serious problems, especially in the light of high relapse rates and the prolonged periods of latency, perhaps induced by suppressive therapy in the field. Within the United States there are many areas where the condition of "anophelinism without malaria" exists. It goes without saying that the military services will not return to civilian life any individual showing clinical symptoms or exhibiting a parasitemia. However, due to the nature of malaria the possibility of undetected latent cases who will relapse or develop into "silent carriers" to serve as foci for the dissemination of this disease cannot be overlooked.

Thus, it is apparent that the weight of malaria control for the present lies heavily upon the Army and the Navy. The Medical Departments of the armed forces are faced with a dual responsibility —first to protect and maintain the military strength of the fighting forces, and second to do all in their power to prevent the in-

troduction or extension of malaria in the civilian population. Success in meeting these obligations is necessary for miltary victory and essential to a healthy peace.

As yet there is much that we do not know about malaria. Today our efforts toward its control are handicapped by not having a drug which is a true causal prophylactic nor a means by which we can determine a cure. Already thousands of malaria patients have been returned to this country and in recognition of our obligation to both the military service and to the civilian communities, the Navy is planning to establish a special facility for the care, treatment and study of these men at a high altitude and in a cool climate. Here, by taking advantage of the normal physiological responses occurring as a result of reduced atmospheric pressure and temperature, we hope to effect a more rapid rehabilitation of these men for further combat duty. In addition it is our intention to undertake special clinical, chemotherapeutic, serological, hematological and parasitological studies which we hope will result in the development of a criteria by which we can reasonably predicate that upon discharge from medical care they will not again relapse. If such a criterion can be established, obviously it would reduce, insofar as it is humanly possible to do so, the danger incident to the return of chronic carriers to civilian communities when the war is over and demobilization occurs.

The Navy takes pride in its malaria control work of the past two years. Not only have the results in the United States been gratifying, but overseas the persistent and conscientious application of those methods of proved value have produced most gratifying results. But these results do not mean we can relax. To minimize the threat of malaria is to jeopardize the war effort. To underestimate the potential post war danger is to add immeasurably to the problems of public health.

THE MALARIA CONTROL PROGRAM OF THE U. S. PUBLIC HEALTH SERVICE AMONG CIVILIANS IN EXTRA-MILITARY AREAS

STANLEY B. FREEBORN
Senior Surgeon (R)
U. S. Public Health Service

Shortly after the Declaration of War funds were made available to the Public Health Service for the control of malaria in the vicinity of war establishments. This function was organized as the Malaria Control in War Areas program under the States Relations Division and headquarters were established in March, 1942 at Atlanta, Georgia.

The function of this program is to protect troops and vital war workers from malarial infection. Following the usual practice of this division of the Service, the operational activities are carried on under the direction of the State Boards of Health with funds, equipment and consultation along technical and policy making lines supplied by the Service. This is a fitting place to pay tribute and acknowledge indebtedness to the State Health Departments which made possible the accomplishments of the program.

SCOPE

Twenty states, the District of Columbia and Puerto Rico are now cooperating on programs in malaria control. In addition twelve cities in five states and the Territory of Hawaii are carrying on campaigns, under the direction of their respective states or territory, for the control of *Aedes* mosquitoes for the prevention of dengue or yellow fever outbreaks.

A total of 1,161 war establishments are being protected, of which 378 are Army installations, 118 are Naval stations, 202 are critical war industries, 463 are recreational or liberty centers for the armed forces and housing developments established for war workers or military personnel.

ORGANIZATION

The operational unit is an "area." Its size and scope is largely dictated by the amount of work that can be directed effectively by one man—the area supervisor. In many cases the area consists of several "zones." These are established within an area where the protected establishments are near enough together to be directed by the area supervisor but separated sufficiently so that the controlled terrain does not overlap. The area supervisor is directly re-

sponsible for the operation of this area and reports to the State health officer. Most State health officers have designated State directors of MCWA programs to act as their representatives.

Associated with the area supervisor are one or more entomological inspectors who search for breeding places, check larviciding efficiency and make routine captures of adult mosquitoes at established stations both within and outside the controlled zones. Their findings are reported weekly both to the Atlanta office and to the MCWA entomologist who is assigned to each State health office.

At the Public Health Service District Office level there are assigned a district MCWA engineer and entomologist. Their function is to visit the various state personnel within their respective districts for consultation on matters of policy and technical direction, to facilitate the flow of supplies and equipment to the states and to be generally helpful and constructively critical to the state programs. Although stationed with the District they are responsible to the Headquarters office for policy and technical direction. However, their correspondence clears through District channels and the District is solely responsible for their activities that are concerned with public relations.

PROCEDURES

This is strictly an emergency program for a specific purpose: the protection of personnel vital to the war effort from malarial infections. Consequently, we are not concerned with pest mosquitoes nor with anophelines other than those known to be natural vectors of the disease. The species sanitation program that we are fostering is largely confined to larviciding procedures directed against *A. quadrimaculatus* in the southeast, *A. freeborni* on the Pacific Coast and *A. albimanus* in Puerto Rico and the Lower Rio Grande Valley. Control operations are restricted to a distance corresponding to the normal flight ranges of these anophelines. The Army and Navy are doing an almost perfect job of control within their respective reservations. Our work in connection with these stations begins at the boundary of the reservation and extends for a mile radius (under normal conditions) around the living quarters of the personnel. In the case of many of the smaller establishments this involves a zone a mile wide around an entire establishment but in the case of some stations, such as the huge divisional camps, the controlled area is simply a mile circle around the actual living quarters of the personnel. This procedure varies at different camps. In the main, we attempt to complement the work being carried on

inside the reservation by controlling a zone outside that will safeguard the protected area.

In the main, oiling or dusting with Paris Green have been the standard larvicidal procedures. Some trials with organic insecticides and emulsified oils which give great promise were carried on late this season. Airplane dusting has been used extensively where it was indicated and in several instances interior spraying has been carried on as a prophylactic measure.

Drainage procedures of two categories have been undertaken. First, those areas that were impossible to larvicide without at least some reduction in water surface by drainage. Second, those areas in which the cost of drainage could be amortized in five years in terms of annual larviciding costs. The use of permanent ditch lining or tile has been limited to a minimum and utilized only where it was mandatory on account of the soil conditions or terrain and only then when the cost of materials was borne by some local governmental subdivision. We have not hesitated to use heavy equipment wherever its use would save manpower. Dynamiting is playing an increasingly important role wherever soil conditions are favorable.

Despite the fact that we have consciously made the "dollar" secondary to the "man-month" in planning our operations the costs have been remarkably low and compare very favorably with pre-depression figures. Including absolutely all items of expenditure the program averages to cost almost exactly a dollar a man-hour for all personnel in the field.

I think some of us who are closest to the work sometimes confuse costs, size of projects, gallons of oil and mosquito densities as criteria of accomplishment whereas our only true measure is the presence, severity, reduction or absence of malaria. In the face of a declining malaria rate it would be presumptuous to take too much credit for our operations. However, it should be made a matter of record that, whatever the cause, the number of cases of malaria acquired in any one of the protected areas has in the great majority of instances been zero and, in the remainder of the areas, the cases have been so few and so scattered as to be practically negligible.

The problems which may be created by malaria carriers returning from overseas duty has given us some concern and has been the subject of numerous conferences and exchanges of correspondence between our Service and the Surgeon Generals offices of both the Army and the Navy. Both of these offices are acutely aware of the potential dangers that are inherent in the situation and have been most helpful to us in our planning.

Our proposed solution of the problem is intimately connected with another proposal concerning the eradication of malaria which will be presented later in this program by Dr. Mountin. However, we have already surveyed or are in the process of surveying all the military establishments, even though they are outside the malarious areas, where concentrations of malaria carriers occur or are expected. These include all general hospitals, prisoner-of-war camps and debarkation centers. When, and if, even moderate densities of vectors are found to be present, control operations around these points are instituted. During the winter we plan to organize a group of mobile units which will be stationed in various parts of the country. These units will be "circuit riders" spreading the gospel and practice of anopheline control around all of these concentration points of malaria carriers. Unlike their progenitors they will not "live off the country" but will be fully equipped to carry on inspection and control at their points of call.

It is planned that these units in addition to doing periodic inspection and control, wherever necessary, around a circuit of general hospitals, prisoner-of-war camps and debarkation centers, will also be available because of their mobility to respond quickly and effectively in case of any outbreak of malaria in the locality that might result from returning carriers. The establishment of these mobile units constitutes a delaying action. The proposal which Dr. Mountin will present later is our main frontal attack.

In recent times we have only had one experience that might throw some light on what we may expect from the introduction of these carriers. Those of you who read John Steinbeck's "Grapes of Wrath" (and thereby misguidedly condemned California ranchers as capitalistic ogres who thrived on human flesh) will recall that beginning in 1934 thousands of agricultural migrants from the Dust Bowl descended on the Pacific Coast en masse. The medical records of the migrant camps that were established showed that malarial relapses were not at all uncommon. The great majority of them lived under very inadequate housing provisions in areas that had been hot beds of malaria thirty to forty years ago. In the three or four years that this condition prevailed in an aggravated form, only two small epidemics of malaria, each of less than 50 cases, occurred. One was entirely confined to migrants in a squatter camp in the Central Sacramento Valley. The other, occurred in a nice home for pest mosquitoes that had been transformed into an ideal camping ground and anopheline habitat by well meant but misguided mosquito control efforts. This epidemic spread to local inhabitants and had to be controlled by anti-anopheline measures. No new cases occurred the next year nor thereafter. In

addition to these there were perhaps a dozen instances where from one to four cases in a limited area could be traced to a migrant carrier but in every case the spread was self-limited.

Although we know that *quadrimaculatus* can transmit some of these new imported strains from the Southwest Pacific and that *freeborni* on the West Coast can develop sporozites of at least one strain of imported *vivax,* we really know very little yet about the behavior of these imported strains. It is well to err on the cautious side and be overprepared rather than unprepared. For this reason the Service is not only attempting to find out as much as possible about the idiosyncrasies of the new strains but we are also preparing for the worst in our planning of anti-anopheline programs for the future.

It is obvious that the thinking and planning of everyone on our program have been thrown into reverse. From a program directed toward the protection of troops from civilian malaria we have, without relaxing the initial mandate, been confronted with the problem of protecting the civilian population from troop-borne malaria.

Some of the younger members of the staff have bitterly bemoaned the absence of fulminating epidemics against which they could tilt their lances. But the older hands have attempted to inspire them with the romance of being a party to the last rites in the United States of one of our arch enemies. I have a sneaking hunch, however, that when and if that day comes we oldsters will feel exactly like an enlisted man who was coming out of the delousing station at Newport News at the close of the last war did when I asked him how he felt now that he was all cleaned up. The answer was, "Mister, I feel just plain lonesome."

MALARIA CONTROL ACTIVITIES OF THE PAN AMERICAN SANITARY BUREAU

HUGH S. CUMMING
Director, Pan American Sanitary Bureau

Before launching into a discussion of the malaria activities of the Pan American Sanitary Bureau, perhaps it will not be amiss to give a brief idea of the institution under my direction since 1920, its scope, duties, activities and organization.

In point of time the Pan American Sanitary Bureau is the oldest of the great international health bodies. Nearly a decade before the International Office of Public Hygiene of Paris and two decades before the Health Section of the League of Nations came into being, the American Republics had already created their own international organization. Unlike these two organizations, however, the Pan American Sanitary Bureau is actively supported by all of the countries in its field of activities, and all of them have shared and are still sharing in its support, work and achievements.

The Bureau was created as an independent official public health organization by the Second International American Conference (1901-02), organized by the First Pan American Sanitary Conference (1902), and reorganized by the Sixth (1920) and successive conferences. It is governed by a Directing Council, elected, together with the Director, at each Pan American Sanitary Conference, and supported by annual quotas contributed pro rata by all the American Republics. On this Council all the republics are represented by rotation.

The original purpose of inter-American cooperation was quarantine standardization, due to the fact that early procedures to prevent introduction of disease into the various ports proved in practice arbitrary and often drastic, long detention of ships and harsh restrictions handicapping commerce. It was primarily in an attempt to put an end to this trade-paralyzing and costly situation that the Pan American Sanitary Conferences and the Pan American Sanitary Bureau were organized by the combined efforts of a number of public health statesmen of all of our republics.

As the major quarantinable diseases, namely, cholera, yellow fever, plague, smallpox and typhus, were gradually brought under control and seaports freed from their ravages, the activities of the Bureau expanded from mere defense against epidemics to actual and constant prevention work. Demands were made upon it to furnish advice on many different subjects, all of them resulting from the development and growth of health activities through-

out Latin America, which, in its turn, the Bureau was also helping to expand and organize on a solid basis. For almost two decades, however, little work was done between conferences. Its activities began to assume more importance after 1920, when the Sixth Pan American Sanitary Conference enlarged the powers and scope of the Bureau and increased its appropriations. The usefulness of the Bureau became even more marked after 1928 and especially after 1938.

Under the provisions of the Pan American Sanitary Code, formulated in 1924, the Sanitary Bureau has gradually become the center of coordination and information in the field of public health for all the American Republics. It also acts as a consulting body at the request of national health authorities, carries on epidemiological and scientific studies, administers a comprehensive fellowship service, and publishes a monthly Bulletin, with a circulation of 10,000 and weekly epidemiologic reports, and prints and distributes much other educational and informative material.

Awakened interest in other problems confronting the American Republics was reflected at the Third International Sanitary Conference (1907) in the opening address of its Chairman, the illustrious Dr. Eduardo Liceaga, at the time National Director of Health of Mexico. "These are other diseases," he stated, "the remedies for which are not unknown, but which do not cause the beneficial alarm produced by the others that we have just mentioned. For instance, malaria not only causes the death of many persons and in terrifying numbers, but also undermines slowly the health of others, impoverishes their blood, weakening it gradually, and therefore disables them for work. It shortens considerably the duration of their lives, and is a powerful factor in the degeneration of the human race." He went on to say that inasmuch as yellow fever was under control in his country the health authorities were devoting their main efforts to a campaign against malaria.

That change of orientation was also reflected in the resolutions adopted by the sanitary conference addressed by Liceaga, which marked indeed the arrival of a new epoch. The Governments represented were asked to carry on active propaganda concerning malaria, distribute free quinine to the poor, direct the maritime sanitary authorities to state in bills of health the mortality caused by malaria, and declare free of fiscal duties all products used in the prevention and treatment of malaria. The Pan American Sanitary Bureau was also instructed to distribute regularly information concerning the existence of malaria in important seaport cities.

After that meeting, malaria became a regular subject on the agenda of all meetings held under the auspices of the Pan American Sanitary Bureau, including all the sanitary conferences proper as well as the quinquennial conferences of the National Directors of Health starting in 1926.

The Fourth Conference (1910) suggested a modification of antimalarial measures in the light of new knowledge obtained, and further recommended that the different Governments distribute in all possible ways data by which people might protect themselves against malaria, especially by publication of instructions to prevent and control the disease and by making it compulsory on the part of employers to supply such instructions and to require their observance by their employees. The Pan American Sanitary Bureau was again asked to compile and distribute data on malaria control, by the Sixth Conference (1920). This was done through a special issue of the Bulletin of the Pan American Union which long remained an authority on this subject and even now may be read profitably.

At the Seventh Pan American Sanitary Conference (1924) emphasis was laid upon the forwarding of data on malaria activities to the Bureau and all cinchona-producing countries were asked to protect and stimulate the quinine industry as a fundamental element in the campaign against malaria, as well as to determine their actual needs of quinine.

It was about this period that the Pan American Conferences of National Directors of Health came into existence and from their very beginning they exhibited a deep interest in this vital problem. The First (1926) recommended the organization of permanent committees or sections for the study and eradication of malaria in the national departments of health of all countries concerned, and the cultivation of greater quantities of cinchona. This resolution, which has gradually been carried into effect everywhere, has proved most far-reaching, since it has permitted long range, well directed programs in malaria control to develop.

The Second Conference of Directors of Health (1931) resolved that rural sanitation, including especially malaria and hookworm disease, be made a topic for study by the next Sanitary Conference.

The Ninth Pan American Sanitary Conference (1934) reviewed at length anti-malarial activities and again recommended that information be sent to the Pan American Sanitary Bureau for publication and distribution, suggesting also that centers of research on the disease should be created in several countries.

The Third Conference of Directors of Health (1936) advised that malaria be given foremost attention in all health work programs.

The Tenth Pan American Sanitary Conference (1938) took one significant step in creating the Pan American Committee on Malaria with a very comprehensive program, including studies of the vectors of the disease, review of laws in force for malaria control and the results obtained, the incidence of malaria in each country, native antimalarial drugs of the New World and standardization of malarial nomenclature. This Committee was appointed by the Director of the Pan American Sanitary Bureau in 1940, its membership including prominent malariologists of Argentina, Central America, Brazil, Mexico, the United States and Venezuela.

The Fourth Conference of Directors of Health (1940) suggested that the Committee submit a plan of work to be used in the campaign against malaria. The Eleventh Pan American Sanitary Conference (1942) recommended, in its turn, that the Committee on Malaria be considered as a consulting organization for the purpose of carrying out surveys and control programs.

From this account of the action which we may call quasi-legislative of the Conferences, we may pass to the work accomplished by the Pan American Sanitary Bureau itself, partly because of the impetus given by the Conferences themselves.

Preferential attention has been given regularly in our Bulletin to emphasizing the public health importance of malaria and reviewing the latest advances in prevention, control and treatment. Throughout the years 1922 to 1925 the Bulletin carried in a prominent place the following appeal, perhaps aiming to arouse the "beneficial alarm" so graphically characterized by Liceaga:

"Malaria has always been a most formidable enemy in tropical and subtropical America. Not only has it hindered the material progress of the countries in these zones, but also it has given them a name for unhealthfulness and hazard, which is the greatest injury possible. Let those interested in the prevention of this scourge write to the Pan American Sanitary Bureau."

Every once in a while we think it wise to reiterate this warning and advice.

A timely paper was published in 1932 insisting on the need of reviving the cultivation of cinchona in Latin America and furnishing complete information on how to grow the plant. This pamphlet, which has been reprinted a number of times, is still in demand. Another original paper published in 1937 dealt with malaria in high altitudes. It was also in the Bulletin that the

first paper on the use of sulfa drugs in malaria was published (1937).

There is hardly any phase of the disease and its control which has failed to be covered, special attention being given to such subjects as prevalence in the various countries; seasonal distribution; preventive measures; value of certain drugs in treatment; drug requirements in the various republics; staining of parasites; natural defenses against mosquitoes; rice cultivation; and legislation adopted.

In response to requests from national and local health authorities, active cooperation in several field projects has been rendered on many an occasion by our traveling representatives. Specific instances are the following: Bolivia, Cochabamba, Chaco and Yungas areas (Hanson, 1939 and 1940), Cochabamba (Hopkins, 1941); and Mizque (Hargis, 1941); Dominican Republic (Murdock and Dashiell, 1941 and 1942); Ecuador, Guayaquil (Komp, 1937; Murdock, 1939 and Hopkins 1940, 1941, 1942, 1943); Bucay and Balzapamba (Hanson, 1937); Chillos Valley (Hanson, 1941); Paraguay (Hanson, 1938, 1939, 1940); Peru, Chanchamayo and Perene Valleys (Hanson, 1937); Lurin and Chimbote areas (Long and Hopkins, 1941 and 1942).

A most ambitious enterprise initiated in 1940 was the preparation of a Pan American Geography of Malaria. This task was entrusted to Dr. Henry Hanson, but unfortunately it was interrupted by his resignation as one of our traveling representatives in 1942 to accept the position of State Health Officer of Florida. Considerable data had, however, been obtained, which it is hoped may still be used for the purpose for which they were intended. A recent interesting study by one of our field engineers has dealt with the use of copper arsenite as a substitute for Paris green.

A very important service of late has been assistance to the different Latin American countries in getting supplies of drugs and materials to be used in anti-malaria campaigns.

Our Pan American Committee on Malaria has not failed to act in accordance with the instructions it has received from the Directors' and the Sanitary Conferences as well as the Bureau itself. While actually created only in 1938, it has already gathered valuable information and paved the way for further advances. A malaria vocabulary, publication of which began in the October Bulletin, has been translated into Spanish and Portuguese, and a Directory of persons interested in malaria in all the republics is in course of preparation. An exhaustive report on malaria activities in the different countries was presented to the Eleventh Conference by the Committee. A complete list of anopheline mosqui-

toes has been compiled for North America and South America. A number of practical suggestions were also offered to the effect that special fellowships be given for the study of malaria at centers to be established, that the interchange of anopheles specimens be intensified, and that a quarterly on malaria be published.

It is planned to put even to better use the services of this Committee with the outstanding experts[1] now giving to it so unselfishly the benefit of their knowledge and experience. Periodical meetings may be arranged and encouragement given to visitors to the places where high type work is being done and should be taken as a guide elsewhere.

Many problems are still awaiting solution in the field of malaria. Some now under careful consideration are: improved classification of vectors; determination of most dangerous vectors in various areas; value of totaquina as compared to other anti-malarials; possible substitutes of Paris green; finding of a shortened method of treatment.

The best cooperation and facilities of the Pan American Sanitary Bureau are available to all those interested in these and similar problems. Their solution will go a long way in helping to control one of the worst scourges of the Americas, which is causing to this day millions of cases of disability and tens of thousands of deaths.

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[1]Dr. Arnoldo Gabaldon, Chairman; Dr. Carlos Alberto Alvarado, Dr. A. S. Ayrosa-Galavo, Dr. V. A. Sutter, Dr. Luis Vargas and Dr. L. L. Williams, members; Dr. Mark F. Boyd and Dr. Henry Hanson, advisors.

MALARIA CONTROL ACTIVITIES OF THE INSTITUTE OF INTER-AMERICAN AFFAIRS

By George C. Dunham, M. D.
Vice President of the Institute of Inter-American Affairs, and Assistant Coordinator

The Inter-American Cooperative Health Services now operating in the other American republics are directing an intensive campaign against the outstanding health problem of malaria. By application of the already known facts concerning this disease and its diagnosis, prevention and treatment, it may be expected that health can be extended in many areas, particularly key defense areas or those producing critical war materials where fatality rates are high and thousands of persons suffer from extreme debilitation with accompanying retardation of social and economic progress.

The situation in a single community may serve as a case in point to exemplify a relatively simple problem and the engineering approach to its solution. Amapala is a town in the Republic of Honduras with a census population, in 1940, of 4,081 inhabitants. The community is considered to be of outstanding economic importance to the country of Honduras, as it is the only Honduran seaport on the Pacific side of the republic and is in a key position in trade relations between the southern part of Honduras and the outside world.

The leading public health problems of the community are reported to be malaria, amebic dysentery and intestinal parasites, with malaria by far the most important. The 13 deaths from malaria reported in 1940 and 1941 show a death rate for this disease of 159 per 100,000 population. In a survey conducted in 1942, the splenic index for Amapala was approximately 36 per cent.

The town is on ground which slopes directly to the sea, with excellent drainage of rainfall, facilitated by a central drainage depression in stone-paved streets. Although rainfall is heavy from May to November, few collections of water which serve as breeding places were found. There are no other streams or watercourses in the area. About one-half mile south of Amapala there is a fresh water lagoon which formerly served as the source of water supply for the town. The body of water has a surface area of about 22 acres, of which about 10 acres were covered with a huge floating mat consisting of dirt, grass and shrubs about 3 feet thick. Because of the high color content of the water, the entire water supply system, including a pumping station and filtration plant, had been abandoned, and the lagoon furnished a serious malaria hazard for

the surrounding area. Field examinations showed it to be an outstanding breeding place for *A. argyritarsis* and *A. albimanus.*

The Service instituted the program of malaria control by clearing the lagoon of its matted growth, filling in the shallower areas on the periphery and developing a margin free of vegetation. Attention will probably be given to the possibility of reclaiming the water supply system as a subsequent project.

Figure No. 1 shows men clearing the floating mat on the lagoon at Amapala, Honduras.

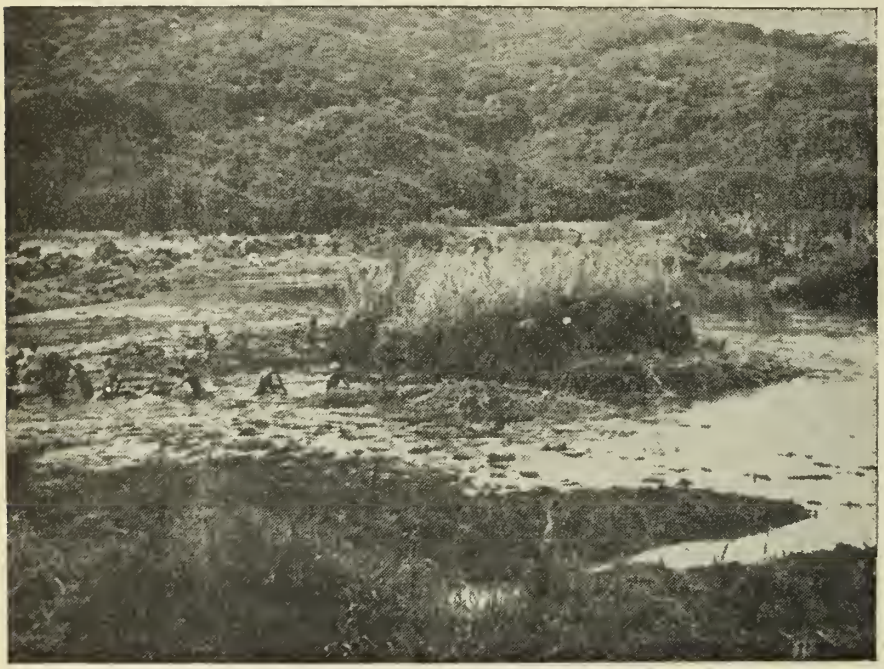

Figure No. 1. *Men Clearing a Floating Mat on the Lagoon at Amapala, Honduras*

In general, the malaria control program of the Inter-American Cooperative Health Services follows the accepted pattern of survey and laboratory studies for direction and evaluation; permanent and temporary measures for the destruction of the aquatic and adult stages of the *Anopheles* mosquito and its breeding places; widespread administration of the antimalaria medicines for clinical prophylaxis and treatment; and the long-term education of professional and technical personnel and of the general public in the principles of malaria prevention and mosquito abatement.

Projects are begun after entomological, medical and engineering surveys have been made. Further studies are continued from

time to time to check progress and indicate the efficiency of the work.

Malaria and mosquito surveys in the field are supplemented by laboratory examination and study. The notable achievement of the "Malaria Control Service of the Northeast" in the eradication of the Gambiae mosquito from Brazil was completed two years earlier than expected by the Brazilian and Rockefeller Founda-

Figure No. 2 shows concrete drainage ditch construction at San Miguel, El Salvador.

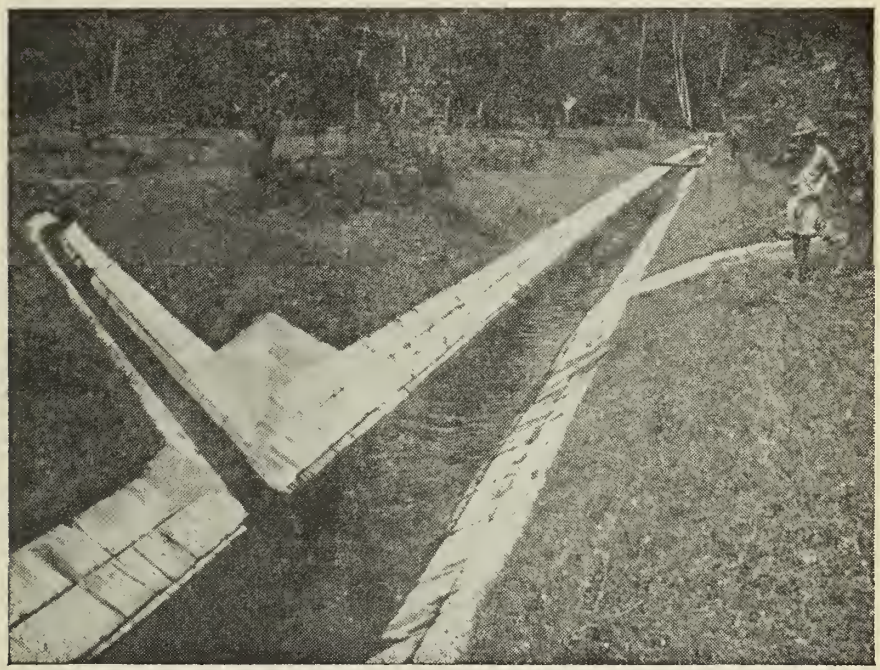

Figure No. 2. *A Concrete Drainage Ditch at San Miguel, El Salvador*

tion staff. The Brazilian staff, equipment and buildings from this service and from the Institute de Patologia Experimental Evandro Chagas in Belem were assigned to the Amazon project of the Cooperative Service by the Brazilian government.

The staff includes a trained entomologist, a microscopist, physicians, technicians and field inspectors. The duties of the inspectors include the collection of entomological specimens, the sampling of population for malaria surveys and the distribution of atabrine. Extensive surveys, chiefly in the Amazon Valley, have included the study of breeding places, feeding habits and parasitic and splenic indices. Twenty-two species of anophelines have been

studied and identified and an illustrated key of the eggs of 30 species has been prepared.

In no other Republic in the Western Hemisphere is entomtomological work being conducted on as extensive a scale as that in Brazil, although an increasing store of information is rapidly becoming available on the species and distribution of anophelines in other Republics.

Figure No. 3 is a view from a mountain of the sub-surface drainage system in the Pomasqui-San Antonio Region. These mosquito breeding valleys are several thousand feet lower than Quito.

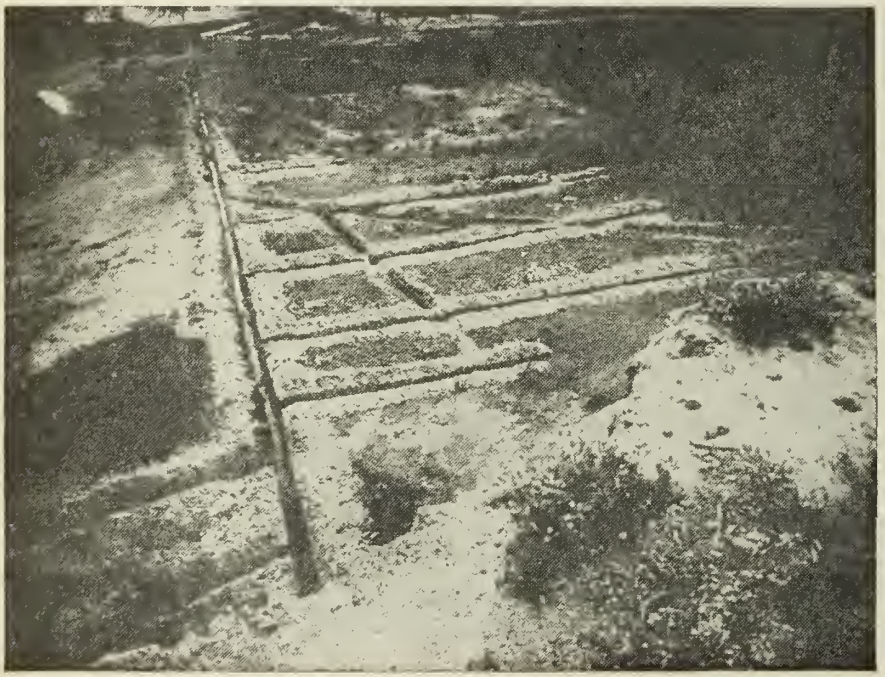

Figure No. 3. *A Sub-Surface Drainage System in the Pomasqui-San Antonio Region Several Thousand Feet Lower than Quito, Ecuador*

Permanent control measures consisting of draining, filling, clearing brush, tide gates, levees, etc., have been initiated in 13 of the countries.

In Ecuador, the mosquito control program has included permanent drainage of swampy areas at Pomasqui, at San Antonio below Quito, and at Tumbaco in the Chillo Valley, a heavily infected district. At the port of Guayaquil, the work has entailed a considerable amount of filling before permanent drainage work began.

Permanent mosquito control measures are under way in all of the Central American Republics, preceded by preliminary surveys. Much of the work is along the proposed route of the Pan American Highway and the Emergency Military Highway, including extensive operations at Guatemala City in the Republic of Guatemala; Sonsonate and San Miguel in El Salvador; Choluteca, Comayaguela and Tegucigalpa, in Honduras; and Managua, Tipitapa, and Rivas, in Nicaragua. Permanent measures are well advanced at San Jose, Guatemala; Acajutla, El Salvador; Amapala, Honduras; Corinto, Nicaragua; and Las Canas, Costa Rica.

In figure No. 4, a Brazilian is spraying larvicidal oil in a swampy area near Belem.

Figure No. 4. *Brazilian Spraying Larvicidal Oil in a Swampy Area Near Belem*

An extensive anti-mosquito campaign is now operating in Panama where, on September 1, 1943, 30 such projects were completed or in operation involving the services of 6 United States and 370 National employees. It is estimated that in Central America alone approximately 504,000 persons should be benefited by the permanent mosquito control operations.

In almost all instances the permanent control measures have been supplemented by such temporary measures as oiling, spraying,

and dusting with Paris green. In some instances such methods alone are possible and should be kept up indefinitely.

This work has been of special moment in connection with the establishment and supervision of air bases, the protection of rubber workers in the Amazon and the sanitation of camps for highway and railroad workers. The project at the Las Mercedes Airport, Nicaragua, Port-au-Prince, Haiti and other bases, combines permanent and temporary control measures. In Nicaragua, Pan American Airways has agreed to finance the permanent measures and the Army is to secure materials required for temporary control. The project consists of plans for (1) cleaning, straightening and paving water course, lowering and enlarging of culverts, construction of subsoil drains and filling of places that cannot be drained; (2) larvicidal control with oil and Paris green during the rainy season when large tracts are under water; (3) periodic spraying of all habitations within the area; and (4) periodic epidemiological surveys for detection of active and latent malaria infections, with control by antimalaria measures.

In cooperation with the Rubber Development Corporation medical care is being provided for rubber workers in Brazil, Colombia, Ecuador, Peru, Venezuela, and the Central American Republics, with the widespread administration of antimalarial medicines as a function of primary importance.

In the Amazon Valley of Brazil, 32 Malaria Control Posts were in operation on September 1, 1943. These stations serve as Centers for treatment of the sick, distribution of antimalarial medicine and, in some instances, provision of temporary mosquito control measures. They are equipped for general therapeutic and preventive services and first aid treatment and are generally under the supervision of a physician assisted by one or more nurses. Before proceeding to the posts, doctors have a post-graduate course of about one and a half months in Belem. They then go into the interior and work one month with one of the veterans on location, after which they are given a post of their own. In addition to the established control posts, atabrine is distributed through other channels throughout the entire Amazon Valley.

The training of personnel is being accomplished through assistance to hospitals, medical schools and schools of nursing, local courses under the auspices of the Services, and by travel grants and fellowships to the United States. Arrangements have been made to use the Cooperative Service in Venezuela for training some men from the other Republics in malaria engineering. Health education of the public is being disseminated through the organization of health centers and methods of community education.

These malaria control programs in all of the phases of operation include mosquito collection, parasitic and splenic surveys, permanent and temporary antimosquito measures, prophylaxis, medical treatment and hospitalization, personnel training and education of the public.

The malaria control program is a part of the concentrated health campaign upon which 17 of the other American republics are now launched, in a joint undertaking with the United States. At the meeting of American Foreign Ministers in January, 1942, recognition was taken of the outstanding importance of the mobilization of vital forces. In the following February a Health and Sanitation Division was established in the Office of the Coordinator of Inter-American Affairs for organization of and participation in the proposed extension of medical and public health work. This Division extends and amplifies the pioneer work done by the International Health Division of the Rockefeller Foundation and the consultant services of the Pan American Sanitary Bureau in some of the southern republics. The machinery constitutes a pioneer venture in a new type of cooperative service, uniting the government agencies of this and other countries. Although this program is the response to an emergency situation the pattern which is being developed offers great promise for the unified development of cooperative effort in this and other fields.

Funds voted by the Congress of the United States were assigned to a corporate unity, the Institute of Inter-American Affairs, set up by the Coordinator with power of attorney to administer funds and execute cooperative agreements with the other American republics. Following conferences and the execution of agreements between this and the other republics, the Cooperative Health Services were formed as an integral part of their National Departments of Health. In the malaria control work, as in all other activities undertaken by these Services, responsibility for the initiation and supervision of all projects and the disbursement of funds is vested in the field representative of the Health and Sanitation Division and a representative of the National Department of Health in each country. Technical field parties sent from the United States are supplemented by local personnel, just as funds and equipment are supplied by both the United States and the participating Republics.

The general plan includes projects concerned with the construction, equipping and operation of hospitals, clinics and health centers; environmental sanitation, including improvement of water supplies; public health surveys including epidemiological investigations with laboratory studies and education of professional and lay groups.

Each of the various activities of the Services is strengthened and promoted by all other phases of the work. Thus malaria control in particular and the disease control program in general are being extended along the same lines of approach. The results of this endeavor are being measured, today in war-time and also in the long-time values resulting from the united efforts of the people of the Western Hemisphere in the field of international public health.

FACILITIES FOR THE TRAINING OF MALARIOLOGISTS IN MILITARY AND CIVIL INSTITUTIONS

By

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*The information in this paper concerning training provided by the Army, Navy and United States Public Health Service was furnished by those organizations, and has been checked by them for accuracy. Official permission has been given for publication.

For the purpose of this paper, malariologists will include medical malariologists (physicians), entomologists, parasitologists, engineers, laboratory and field technicians, and research personnel. Most of the training of malariologists since the outbreak of the war has been conducted by the Army, the Navy and the U. S. Public Health Service. They have had the cooperation of the Tennessee Valley Authority, the Florida State Board of Health and the Rockefeller Foundation. In addition certain specialized training has been provided by institutions conducting research on malaria under government contract.

Training Provided by the Army

The training of malariologists by the Army begins in many cases for Medical and Sanitary Corps officers in the Basic Course for Medical Department officers at the Medical Field Service School, Carlisle Barracks, Pennsylvania. At this post additional training in malaria control is available to officers assigned to the Medical and Field Sanitary Inspectors' course. For some officers, training in malariology is provided by courses in Clinical Laboratory work conducted at civilian institutions. In this course the identification of the malaria parasites and the identification and control of mosquitoes are given considerable emphasis. Training for medical officers in malariology is provided in the eight-week course in tropical medicine given at the Army Medical School and also at Tulane University. At the Army Medical School approximately 40 hours of instruction are devoted to malaria and mosquitoes. The lectures and demonstrations cover all phases of malariology with adequate provision for laboratory exercises on the subject.

Medical and Sanitary Corps officers who have shown particular interest in malaria are assigned for special field training in malaria control. During the summer and fall of 1942 these special field training courses were conducted by the Tennessee Valley Authority. With the onset of the winter season the course

was given in Florida under the sponsorship of the Florida State Board of Health and with the cooperation of The Rockefeller Foundation and the United States Public Health Service.

The course at the Tennessee Valley Authority covered a period of two weeks. It was conducted at Wilson Dam by the malaria control staff of the Division of Health and Sanitation. It consisted of demonstrations of malaria surveys, various types of larvicidal operations including airplane dusting, boat oiling and dusting and hand oiling and dusting, shoreline conditioning, control of aquatic growth, marginal drainage and water level management. It also included observations of the biology of anopheline and culicine mosquitoes, methods of collecting adults and larvae, and the screening and mosquito-proofing of houses. Altogether, six courses were conducted, with an attendance of approximately 65 Army officers.

The course sponsored by the Florida State Board of Health covers a period of three weeks. It is under the Bureau of Malaria Control and is directed by Dr. John E. Elmendorf, Jr. The first week of the course is held at Jacksonville and consists of informal lectures, field demonstrations of methods of collecting adult and larval mosquitoes, practice in leveling, inspection of drainage projects, participation in spleen and blood surveys, use of dynamite in ditch construction and demonstration of larvicidal equipment. The second week is spent in Tallahassee with Dr. Mark F. Boyd at the Station for Malaria Research. It consists of practice in laboratory technique, identification of adult and larval mosquitoes, staining and examination of blood smears, examination of demonstration slides, and dissection of mosquitoes. The third week starts in Tallahassee with practice in the use of larvicides and the demonstration of spray killing of adults. The students then go to Pensacola where the manufacture and installation of concrete ditch lining, subsoil drainage, experimental wells, and the construction and maintenance of screening are demonstrated. A mimeographed manual has been prepared for this course by Dr. Elmendorf and his staff.

Through the cooperation of the Pan American Highway Commission, Army officers have received special field experience in Central America for a period of about six weeks in connection with the construction of the Pan American Highway. This work has been conducted with the assistance of the Health and Sanitation Division of the Office of the Coordinator of Inter-American Affairs in Guatemala, Honduras and Costa Rica. It has consisted of the preparation of kits for malaria surveys, the setting up of laboratories, the carrying out of spleen and parasite surveys, the collection and identification of adult and larval mosquitoes, the use of

larvicides and insecticide sprays, and the outlining of a program of malaria control.

The Army also conducts courses of instruction in phases of malariology for enlisted personnel. Noncommissioned personnel assigned to medical laboratory work receive instruction in the identification of malaria parasites in training provided at Medical Department Enlisted Technician Schools.

A special program in malaria control is prescribed for enlisted personnel who are assigned to malaria survey units and to malaria control units. This instruction, which is mostly technical, occupies a period of four weeks and is given by officers of these units under the supervision of Medical Corps officers. Both types of units are given an introduction to malariology and demonstrations of mosquito breeding and resting places, traps, sampling equipment, and laboratory methods. The malaria survey units receive instruction in the technique of thick smear blood surveys, identification of malaria parasites, the use of mosquito collecting equipment, and methods of conducting preliminary mosquito surveys, preparation and reading of maps, and checking the effectiveness of malaria control work. The malaria control units receive instruction and practice in elimination and larvicidal treatment of breeding places, mosquito proofing of houses, spray killing of adults, and naturalistic methods of malaria control. They also have practice in leveling and transit work, map reading and sketching.

Of special importance to the Army's training program for malariologists is the recently authorized Army School of Malariology which is in the process of being established in Panama. Plans call for a teaching and administrative staff, with provision for adequate supplies and equipment. The school will conduct courses for Medical and Sanitary Corps officers of four weeks duration. The training will consist of demonstrations and field work in malaria control. In addition, this school will provide supervision for practical field training of malaria survey and control units which have completed their basic and technical training.

Training Provided by the Navy

The Navy has a number of methods of training its officers and enlisted men in malariology. To date 323 medical officers have taken a basic course of nine weeks duration containing 53 hours of malariology at the Naval Medical School and at Quantico, Virginia. Seventy-six have taken a twenty-weeks course in Epidemiology which contains 100 hours of malariology at the Naval Medical School. Four have taken the three-weeks course in practical malariology given by the Florida State Board of Health. Four

have taken an intensive six to eight weeks course given by the Malaria Control Headquarters in the South Pacific.

H-V (S) officers, mainly entomologists and parasitologists, do not take the basic course for medical officers at the Naval Medical School and Quantico, but 7 of them have taken the course in epidemiology, 63 have taken a special course in malariology occupying 210 hours at the Naval Medical School, 36 have taken the three weeks course in Florida and 4 have taken the course in the South Pacific. In addition 31 direct from civilian life have received didatic and field training in malaria at New River, North Carolina.

Naval hospital corpsmen also take the courses in epidemiology and malariology at the Naval Medical School, to date 206 having taken epidemiology and 173 malariology. In addition some of them have been given practical training in mosquito identification and larvicidal operation at New River, North Carolina. Corpsmen have also taken the course in Malariology in the South Pacific.

Officers and men of the Construction Battalions ("Seabees") also receive practical training. The officers and chiefs of all Construction Battalions are given a four-hour lecture course and a one-half day trip on malaria and malaria control. In addition, ten rated men from each Battalion are given a two-weeks course in field malaria control work. The men in this group are those who will serve as labor supervisors in control work in the field with the Sanitary Section of the Construction Battalions. In all, approximately 1000 men have received special training in malaria and malaria control to date.

General laboratory technicians receive twenty-nine hours of instruction on the identification of malaria parasites during a course of sixteen weeks at the Naval Medical School. To date 354 technicians have taken this course

Training Provided by the U. S. Public Health Service

The malaria training program of the U. S. Public Health Service is a part of the program for Malaria Control in War areas with headquarters in Atlanta, Georgia. A basic course of six to eight weeks has been developed for regular corps medical officers and others who may be assigned to malaria control work. This course consists of two weeks in the headquarters office, becoming familiar with the fundamental problems of malaria and the essential elements of present methods of control in this country, one week of intensive work on parasites and clinical malaria at the

National Institute of Health laboratory in Columbia, South Carolina, one week on the identification and ecology of mosquitoes at a field station, usually in cooperation with a state health department, and two to four weeks of field experience on malaria control projects, with participation in all of the procedures supplemented by observation, reading, and personal contact with experienced workers in malaria.

Those men who show an interest in, and aptitute for, a possible career in malariology continue for a period of from six months to a year working in responsible positions in observation and administration of control programs in this country, in malarial research or in other phases of malaria activity. Up to the present time directed training as outlined above has been provided to 12 medical officers of the Service for periods of one month to one year, to 9 South American Fellows (5 physicians and 4 engineers) for periods of one week to three months, and to 40 entomologists and 20 engineers for periods from one to three weeks.

Training by supervised experience alone, including some formal instruction by staffs of state health departments, has been conducted in the various malaria control areas in which the U. S. Public Health Service is operating. Groups of considerable size have thus been accommodated. To date 100 engineers, 100 entomologists and 200 subprofessional workers have received this type of instruction.

In order to make it possible to conduct instruction continuously in the headquarters office in Atlanta, even in the absence of expert instructors, a training and educational section has been established which is collecting or producing visual and auditory teaching material which can be used by students individually or in groups whenever they are able to use it. This material consists of motion pictures, lantern slides, microscopes, parasitological and entomological specimens, and selected references to literature. This can take the place of the first week of the regular course and can be supplemented by instruction from staff members when they are available. With the development of field training stations a similar opportunity will be available for participation in control procedures. Such stations are now being developed.

Training in Civilian Research Institutions

This report would not be complete without mentioning the opportunities in the development of malariologists offered by the intensive research on malaria which is being conducted in this country at the present time. Most of this research is on chemotherapy, but some of it is directly concerned with the biological,

physiological or clinical aspects of the disease. It involves a large number of individuals in the fields of biochemistry, physiology, parasitology and clinical medicine, and is introducing some of them for the first time to this most important field. Their observations have already led to important advances in our knowledge of the malaria parasites, and to the conditions necessary for effective treatment, and their continued interest should add further knowledge in the future. A few medical officers of the Army and Navy have been assigned to one of the research projects for periods of a few days to several months in order to learn the chemical methods and criteria necessary for controlled therapeutic tests on a quantitative basis. Some of these individuals are now participating in such observations among the armed forces in the field. If a small nucleus of teaching personnel could be assigned to the instruction of medical officers and chemists in the quantitative study of therapy, and if more officers could be trained, it would undoubtedly contribute to the solution of problems related to suppressive therapy and the treatment of relapses.

Conclusion

The authorities of the Army, Navy and Public Health Service are to be congratulated on the provisions they have made for the development of highly trained personnel for the study and control of malaria both in this country and in the areas of military activity. Such training should not only contribute greatly to the winning of the war but it should also contribute to the reduction of malaria in the post-war period, and to the solution of some of the difficult problems associated with the disease.

CONTRIBUTIONS OF THE BUREAU OF ENTOMOLOGY AND PLANT QUARANTINE OF THE DEPARTMENT OF AGRICULTURE TO THE NATIONAL PROGRAM FOR THE CONTROL OF MALARIA.

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It has been abundantly demonstrated that the most important factor in antimalaria work is mosquito control. It is logical, therefore, to assume that entomology and the entomologist should play an important part in this vital phase of preventive medicine. It is also logical to suppose that much of the fundamental knowledge of the physiology, toxicology, habits, ecology, and control procedures accumulated by entomologists in their study and control of the thousands of insect pests can and should be brought to bear on the problem of protecting the health and comfort of our fighting men and those on the home front. In gathering this basic information the Bureau of Entomology and Plant Quarantine has played a conspicuous part for many years. In 1854 an entomologist, Townend Glover, was appointed in the U. S. Patent Office to deal with insect problems. This was prior to the establishment of the Department of Agriculture, which took place in 1862. In the following year (1863) the Division of Entomology was established, in 1904 it became a Bureau, and subsequently, in 1934, it was consolidated with the Bureau of Plant Quarantine to become the Bureau of Entomology and Plant Quarantine.

From the modest beginning with one to five entomologists in the eighties and nineties, the Bureau has grown until it now has approximately 2,400 employees and an annual budget of more than 9 million dollars. While a considerable part of these employees and funds is devoted to undertakings in large-scale control of insects and diseases, such as grasshoppers, the Mormon cricket, white-fringed beetles, the pink bollworm, white-pine blister rust, and Dutch elm disease, research on the habits of insects and methods of controlling them by various artificial and natural means has proceeded on a sizable scale, and much of the information has been made available through numerous bulletins, books, and circulars, as well as film strips, motion pictures, and other media.

As early as 1890 some attention was directed to insects of veterinary and medical importance. Investigational work in these fields, however, was conducted on an incidental and sporadic basis for a number of years. It was not until 1926 that a separate Divi-

sion was set up to deal specifically with insect pests of man and animals.

Although the number of men engaged in research on mosquitoes has been very small (3 to 8), results obtained have been of material value in furthering antimalaria work. Among these might be mentioned the work on mosquitoes, by L. O. Howard (1); the study of the effect of malaria on southern agriculture and experiments with the impounding of water on Anopheles breeding, by D. L. Van Dine (2) (3); the development of the precipitin test for identifying blood meals in mosquitoes, by W. V. King and C. G. Bull (4); and the development of methods of applying mosquito larvicides by air plane, by King and Bradley (5).

It is fortunate that information gathered on methods of controlling agricultural pests is often directly or indirectly helpful in combating pests of medical importance, and that the organization and procedures for carrying out large-scale control and quarantine operations against agricultural pests are largely applicable to problems in medical entomology.

To meet war problems the Bureau has modified its research program. Long-time and fundamental research has been largely set aside in favor of investigations of the most immediate and practical application, and some of the personnel of the Bureau have been working in close cooperation with the offices of the Army and Navy concerned with problems in preventive medicine.

To supplement published information on mosquitoes and other insects of importance from a military point of view, a series of 26 circulars referred to as the "Defense Series" was issued, beginning in 1941. The demand for these, especially the one on mosquito control (6), indicates that they have been serving a useful purpose.

In November 1941 a member of the staff of the Bureau, W. G. Bruce, was designated as liaison officer between the Division of Insects Affecting Man and Animals of the Bureau and the military and other agencies concerned with the protection of men in training in this country. His work was conducted with funds provided for the purpose by Congress through budgetary channels. Mr. Bruce made contacts with the medical officers in each of the nine Army Service Command headquarters in the United States, and from these points he worked among a large number of army camps to aid in insect control. Likewise, most of the larger naval stations and a large number of air fields were contacted. Aid was given in making mosquito surveys and in advising on practical control measures. This service of the Bureau was not only greatly appreciated, but was greatly needed, because many of the military

establishments did not have the services of an experienced entomologist.

Several entomologists engaged in research or control operations in the Bureau were transferred to responsible positions in the U. S. Public Health Service, where their knowledge and experience could be brought to bear on the problem of dealing with mosquitoes in extra-cantonment areas. In addition, a substantial number of members of the Bureau research and control staff were commissioned for entomological work in the Sanitary Corps of the Army and the Hospital Corps Volunteer Service of the Navy.

TAXONOMY

The importance of accurate identification of mosquitoes is coming more and more to be recognized. Effective antimalaria operations in a given locality are dependent on a definite knowledge of the species of *Anopheles* involved in the transmission of malaria in that area, which in turn requires a knowledge of the taxonomic characters and habits of mosquitoes. Species sanitation, regarding which we have heard so much in recent years and which has made it possible to accomplish striking results in malaria control at reduced costs, is absolutely dependent upon accurate identification of the Anopheles fauna of the locality. The classic work of Howard, Dyar, and Knab, "The Mosquitoes of the Americas," published in 1912-1917 (7), and such subsequent contributions as "Mosquitoes of North America," by H. G. Dyar (8) and "The Mosquitoes of the Southeastern States," by King, Bradley, and McNeel (9) have done much to further this aspect of antimalarial work in North America.

An immediate and direct contribution of the Bureau to the malaria problems presented by the war is the availability on its staff of a highly competent and willing mosquito taxonomist, Alan Stone, of the Division of Insect Identification, with access to an extensive collection of identified mosquitoes from all quarters of the globe. Dr. Stone had an important part in the preparation of the recently issued War Department publication entitled "Keys to the Anopheline Mosquitoes of the World, with Notes on Their Identification, Distribution, Biology, and Relation to Malaria" (10). During the last 15 months he gave personal assistance or instruction in identification of anopheline mosquitoes to 110 officers of the Army, Navy, and Public Health Service.

Upon request, the Office of the Surgeon General, War Department, was supplied with concise, organized data on insects of medical importance occurring in various parts of the world, with

special emphasis on malaria vectors. The territory covered included all countries bordering the Mediterranean Sea, Rumania, Arabia, Iraq, Iran, India, Burma, southern China, Malaya, the Philippine Islands, Australia, New Zealand, and the islands of the south and southwest Pacific. Information dealing with insects of the Australian and Oriental Regions was also made available, on request, to the Bureau of Medicine and Surgery, Navy Department.

During the period July 1, 1942, to September 30, 1943, 84 lots of anopheline mosquitoes were received for identification, mostly from the Army and Navy. This material, in large part, represented the more difficult forms, the identification of which was giving entomologists in the military services a good deal of trouble. The more easily recognized and common species are seldom included in lots received from those sources. It is expected that the volume of material submitted for identification will increase considerably in the near future as the result of directives recently sent by the military agencies to their malaria survey and control units in the field.

SURVEYS

Through the work of several members of the staff of the Bureau, and the cooperation of various Federal and State agencies and many individuals, a vast store of knowledge has been built up during the years on the distribution and intensity of anopheline infestation in various parts of this country and other parts of the world in which we are now interested. This information has been gathered through the exchange of data and specimens and by hand collection of adult and larval mosquitoes, and especially by the extensive use of traps. It has formed a very useful background for antimalaria operations in military training areas in this country, and in the protection of troops overseas. The staff of the Bureau contributed largely to the survey methods and procedures that have become more or less standardized.

During the last two years the Bureau laboratory dealing with mosquito problems of the Northwest, located in Portland, Oreg., has given increasing attention to *Anopheles* mosquitoes in Oregon and Washington. C. M. Gjullin and W. W. Yates of that laboratory have cooperated with officials responsible for *Anopheles* control around Camp Adair at Corvallis, Oreg., and Camp White at Medford, Oreg. Several inspection and collecting trips were made to these areas, and plans for *Anopheles* control were developed.

As reported by the Oregon Public Health Service, there were 50 new malaria cases in Oregon in 1942 and only 18 in 1943. In 1943, however, malaria was reported from 5 counties that had reported no cases in 1942. The reduction in cases in 1943 evidently reflects the unfavorable season for *Anopheles* activity. Trap-collection records for 1943 have not been completed. In 1942 eight New Jersey light traps were operated in Yakima and Walla Walla Counties, Wash., and 6 in Oregon.

INSECTICIDE INVESTIGATIONS

Since the demonstration in 1892 (11) by Dr. L. O. Howard, then Chief of the Bureau of Entomology, that kerosene is effective in killing mosquito larvae, larvicides have been widely employed and considerable research has been done in this field. Petroleum oils are still the most generally used materials against mosquito larvae, and even now there is need for more research in this field.

Recent investigations conducted at the Portland, Oreg., laboratory of the Bureau, by Knipling, Gjullin, and Yates (12), have shown that by adding certain emulsifying agents to the oils their effectiveness is increased materially. The addition of 4 percent of the emulsifier to 1 part of fuel oil and 6 parts of water produces a spray that gives a satisfactory kill of mosquito larvae when applied at the rate of about 30 gallons per acre. When this emulsion is used, the amount of oil required is reduced from 20-40 gallons per acre to 6 gallons. Not only is a considerable saving of oil effected, but the cost and the difficulty of getting the larvicide to points of use are reduced.

In its efforts to discover and develop insecticides that are more effective, and are less poisonous to man, the chemists in the Division of Insecticide Investigations have synthesized and prepared many materials for testing by other Divisions of the Bureau against numerous insect pests. Of these, phenothiazine, phenoxathiin, and several azo compounds, such as p-(bromophenylazo)-phenol, were found to be distinctly toxic to mosquito larvae. The first of these has been shown by King (13) to kill mosquito larvae when dispersed in water at the rate of 1 part to 2 million. More recent work has shown that another synthetic organic has much promise, and further investigations are in progress.

Considerable attention has also been paid by mechanical engineers and entomologists of the Bureau to the development of equipment for the more effective and economical distribution of insecticides by hand guns, power dusters, and airplanes.

Studies in insect physiology and toxicology are contributing a background of information requisite to a better understanding of

how insecticides affect insects. Results obtained by J. F. Yeager and S. C. Munson, of the Bureau, have indicated that the insect blood cells, particularly the phagocytes, may constitute part of an internal defense mechanism in the insect's body and that the insect's resistance to an insecticide can be affected by altering these cells. By means of these studies more definite concepts of certain features of insecticidal action are being obtained.

The need for a more lasting anopheline larvicide than oils or paris green is generally recognized. In connection with research designed to find materials that would persist on the water surface without losing their toxicity, J. F. Yeager and C. S. Wilson developed a laboratory method of exposing floating dusts to artificial rain. They also developed a method of preparing insecticidal dusts by coating water-soluble or water-insoluble poisons with other substances. The highly toxic and relatively heavy sodium arsenite, for instance, was rendered suitable for dusting by coating it with stearic acid or a stearate.

At the request of the Medical Corps of the Army and upon recommendation of the Committee on Medical Research, a contract was entered into between the Office of Scientific Research and Development and the Bureau of Entomology and Plant Quarantine to provide for an intensive investigation of mosquito larvicides. This work was begun August 28, 1942, at the Orlando, Fla., laboratory of the Bureau under the leadership of E. F. Knipling and C. C. Deonier. Various arsenicals and other inorganic materials were first investigated. None was found to be distinctly superior to coated or floatable Paris green, although copper arsenite appeared to be somewhat more effective. Work with various coating materials was carried on, and stearic acid was found to be the most satisfactory. This material applied to Paris green increased the lasting qualities of the insecticide in proportion to the amount added: however, when too much stearic acid was used, the material was difficult to prepare and apply.

SPRAYS

Several Divisions of the Bureau have made substantial contributions to the development of materials and methods for the destruction of adult mosquitoes. The idea that the systematic destruction of adult anophelines should be a valuable aid in malaria control has been held by many entomologists and others for some time, but a demonstration of the practical value of this line of attack as carried out in India by Paul F. Russell and F. W. Knipe, of the Rockefeller Foundation (14), was required to bring about its general recognition as an antimalarial measure.

Pyrethrum extracts have been depended upon almost entirely for use as antimosquito sprays. The Bureau has cooperated with the National Association of Insecticide and Disinfectant Manufacturers in the development of a standardized method of testing fly sprays. Although this test is based on flies, the Official Test Insecticide of the N.A.I.D.M. is a pyrethrum spray that is used in many parts of the world as a standard for evaluating mosquito sprays. At the present time it contains approximately 0.1 percent (weight per volume) of pyrethrins. A spray no more effective against flies than this standard material is rated, but not labeled, as a B Grade spray. Better sprays that kill 16 percent more flies are labeled as AA Grade sprays. Many of the sprays now sold for the control of flies and mosquitoes are AA sprays. The Bureau in this way, by its cooperative work with the insecticide manufacturers, has brought about a marked improvement in the quality of the sprays sold, which in turn has been effective in reducing the mosquito population in malarious areas where these sprays are used.

The shortage of pyrethrum has stimulated research on possible substitutes for this highly effective insecticide, and on means of making available supplies go further. The discovery in 1940 by Eagleson (15, 16), of this Bureau, that sesame oil added to pyrethrum extract acts as a synergist or activator, pointed the way in this field. Sesame oil is outstanding in this respect, but other materials have been found which act in a similar way. Among these are N-isobutylundecyleneamide and ethylene glycol ether of pinene. Sesame oil owes its synergistic value to a compound known as sesamin. A study of this complex organic compound has led to the preparation, by this Bureau's Division of Insecticide Investigations, of materials simpler in structure. Several compounds, particularly N-substituted piperonylamides, have been shown to be of value in stepping up the toxicity of pyrethrum.

AEROSOLS IN MOSQUITO CONTROL

The method of application of an insecticide is often as important to effective results as the choice of the insecticide itself. In 1942 Sullivan, Goodhue, and Fales (17) of this Bureau published results of research with the dispersal of insecticides in the form of aerosols. Initial work by these authors (18) was concerned with the spraying of insecticides on a hot surface, and investigations along this promising line are being continued. Later the insecticides were incorporated in liquified gas, which when released leaves the particles floating in the air as a mist, which remains much longer than do particles dispersed from an ordinary

liquid sprayer. A number of different insecticides may be applied in this way but the safest and most effective aerosol developed consists of pyrethrum concentrate, sesame oil, and dichlorodifluoromethane, the common refrigerant known as Freon 12. This aerosol is nontoxic and practically nonirritating to man and animals, noninflammable, and exceedingly toxic to mosquitoes. In this form less than 5 milligrams or one small drop of pyrethrins will kill all the mosquitoes in a room containing 1,000 cubic feet of space. In cooperation with the Bureau some manufacturing companies have developed suitable containers and methods of releasing this material, and these "aerosol bombs," as they are known, are used in large numbers for the protection of our armed forces in malarious areas overseas. These devices are well adapted for destroying mosquitoes and other free-flying insects in airplanes. They may thus play an important part in preventing the spread of disease-bearing and destructive insects through the ever-increasing movement of aircraft.

REPELLENTS

In general, entomologists have not favored the use of materials designed to drive insects from one person, animal, or plant to another, but rather have stressed prevention of breeding and methods of destroying the insects. Conditions of combat usually preclude the institution of preventive measures, and repellents have an important place.

At the time of our entry into the war no suitable repellent was available for use by the Armed Forces, and the need for a good one was acute. At the request of the Medical Corps of the Army and with the approval of the Committee on Medical Sciences, a contract was entered into between the Office of Scientific Research and Development and the Bureau of Entomology and Plant Quarantine for the latter to study this problem. Accordingly, investigations were begun at Orlando, Fla., under the guidance of W. E. Dove, E. F. Knipling and B. V. Tavis. Many proprietary materials that were being sold for civilian use were evaluated, and those that had been found by various workers to possess repellent properties were given thorough tests.

As a result of early tests with available repellents or new compounds that could be produced on a commercial scale, three materials proved sufficiently effective and safe to be recommended for use by the Armed Forces. These materials are dimethyl phthalate, Rutgers 612, and Indalone. Many laboratory tests have been made with these materials against *Aedes aegypti*. Under these conditions Rutgers 612 has proved the most effective against this species and provides protection for an average of approximately 5 hours. Di-

methyl phthalate and Indalone protect for averages of approximately 4 and 3 hours, respectively, under the same conditions.

In laboratory tests against *Anopheles quadrimaculatus,* Indalone proved ineffective, whereas Rutgers 612 was moderately effective and dimethyl phthalate was most effective. Results of tests with repellents against this species have proved very erratic, and in some tests the average protection time of dimethyl phthalate has fallen as low as 1½ hours, whereas normally this repellent protects for appoximately 4 hours.

Preliminary investigations indicate that a mixture of these materials in about the proportions by volume of 6 parts of dimethyl phthalate, 2 parts Rutgers 612, and 2 parts of Indalone, is likely to prove more satisfactory against various species of mosquitoes and other insects and mites than any one of the materials.

Several factors are known to influence the duration of repellency. Differences in reaction of various species of mosquitoes and differences among persons are important factors, as indicated by various individuals and agencies that have cooperated in evaluating mosquito repellents. Repellents are less effective when subjects are perspiring freely and when their activities are such that some of the repellent is rubbed off the skin.

The possibility of incorporating repellents in adhesives and camouflage creams, is being investigated, and the results are promising. When applied to clothing these materials are far more effective and longer lasting than when placed on the skin. Applications to clothing at the same rate as to the skin will prevent mosquitoes from biting through treated clothing for several days.

During the course of these investigations approximately 1,000 new repellent materials were tested in the laboratory. Many of these were furnished by the manufacturers, who often made initial tests that screened out those materials of no repellent value. Other materials were furnished through cooperation of the British Central Scientific Office and the Dominion Entomologist of Canada. Of these many materials, the vast majority were found to be worthless; several, however, have proved comparable to the repellents now being issued for military use, and are worthy of further study.

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THE ACTIVITIES OF THE NATIONAL RESEARCH COUNCIL IN THE NATIONAL PROGRAM FOR THE CONTROL OF MALARIA

By George A. Carden, Jr., M.D.

Most of you, I know, are familiar with the background and general functions of the National Research Council. As the active agent of the National Academy of Sciences, the Council was created in 1916 by order of President Wilson to advise the Government on scientific matters in relation to the war and to survey and stimulate research in various scientific fields. The Council draws its members from the representatives of the national scientific societies.

The Division of Medical Sciences under the chairmanship of Dr. Lewis H. Weed has been charged by the Surgeons General of the Army and Navy with many military and naval medical problems. The fact that there are now functioning under the Division of Medical Sciences twelve main committees and fifty odd subcommittees illustrates the scope and intensity of its activities. These committees and subcommittees have two main responsibilities; first, to render advice on the basis of present knowledge; and second, to stimulate, guide and correlate new lines of investigation.

In this latter capacity another important organization enters the picture. The medical division of the Office of Scientific Research and Development is embodied in the Committee on Medical Research of which Dr. A. N. Richards is chairman. This Committee receives advice from the committees of the Division of Medical Sciences, but makes the final decision on all new proposals and renewals of contracts for investigations, and administers the funds for these studies.

On September 3, 1941, the Chairman of the Division of Medical Sciences of the National Research Council called the first Conference on the Chemotherapy of Malaria. At that Conference the importance of concentrating the attack on malaria toward the development of better chemotherapy in the hope of eventually encountering an effective field prophylatic was emphasized.

It was the consensus of the conference group that an attempt to control malaria through the vectors was a long time project, and that the immediate attack on malaria control will have to be with chemotherapeutic agents.

In consequence a research program was gradually developed under the guidance of a "Coordinating Committee" of which Dr.

Frederic M. Hanes was chairman, later under a combined Army-Navy- U.S. Public Health Service-Office of Scientific Research and Development-National Research Council Board under the chairmanship of Dr. Robert F. Loeb. The representatives on this Board have been designated by their respective offices with authority to effectuate an overall program. Under the Board of the Coordination of Malarial Studies are the following four panels:

1) *The Panel on the Synthesis of Antimalarials* under the chairmanship of Dr. W. Mansfield Clark, Chairman of the Division of Chemistry of the National Research Council, is charged with the responsibility of tapping the chemical resources of the country to produce new compounds with antimalarial activity, or to change existing compounds to improve their absorption, excretion, toxicity or antimalarial action.

2) *The Panel on the Biochemistry of Antimalarials,* also under the chairmanship of Dr. Clark, is endeavoring to uncover significant leads in the mechanism of action of parasite on host and of drug on parasite in order to guide the Panel on Synthesis into promising channels in the synthetic chemistry of antimalarials.

3) *The Panel on Pharmacology,* under the chairmanship of Dr. E. K. Marshall, Jr., is responsible for the screening of compounds in chicken, duck and monkey malaria and in conducting toxicological studies on the active compounds to clear these for tests in man.

4) *The Panel on Clinical Testing,* under the chairmanship of Dr. James A. Shannon, has two main responsibilities (i) to conduct quantitative studies designed to improve present regimes of therapy and suppression; (ii) to study quantitatively in man the pharmacological behavior (absorption, excretion, distribution and degradation) and toxicity of new compounds; to evaluate in induced malaria in man the antimalarial activity, both in therapy and in prophylaxis, of promising compounds.

The activities of these four Panels are integrated in the Board for the Coordination of Malarial Studies, and the chairman of each panel is a member of the Board. The research studies under its aegis are supported by contracts with the Office of Scientific Research and Development through the Committee on Medical Research.

The Synthesis and Biochemistry of Antimalarials: Information on the chemical structures of new drugs and on their antimalarial activities as tested on bird malarias flows into the Survey of Antimalarial Drugs, an office established under contract between OSRD and the Johns Hopkins University. It is believed that practically the entire body of such information available in the United States

is thus centralized. It comes from 33 industrial research laboratories, seven research foundations and numerous college and university laboratories and, of course, includes all material submitted by the Government contractors. Since its establishment in July 1942, the Survey has filed records of about 6,000 new drugs which have been tested on one or more parasites.

Exchange of information through the Survey is conserving manpower by avoidance of duplication of effort. This latest review of the more promising of the 6,000 drugs, which supersedes previous reviews of certain groups, should accelerate that concentration of effort which will be necessary if the manifold chemical and pharmacological studies preceding clinical trials are to focus upon the limited number of compounds which can be handled by the available clinical investigators.

In order to supplement the synthesis of new compounds by those who are cooperating with the Survey and to develop special leads discovered by the testing laboratories, the Panel on the Synthesis of Antimalarial Drugs has organized and is supervising the work of 25 university laboratories under OSRD contracts. The immediate supervision is under regional directors for the Eastern, Middle-West, and Pacific Coast areas. Fifty-one chemists are giving full time and about 122 chemists, including graduate students, are giving part time to new syntheses.

In addition to these chemical investigations, which are centered by the thought of immediate practical application, investigations by another Panel, the Panel on the Biochemistry of Antimalarial Drugs, are concerned with distinct parts of the overall relations of host, parasite and drug. With no illusions that all of the complex relations can be understood in a short time, the investigators hope to find leads of a type that can be subjected to direct practical tests for which clinical material may be necessary.

The Pharmacology of Antimalarials: Pharmacological studies in the malarial program include the testing of a large number of chemical compounds for potential antimalarial activity in experimental malarial infections in birds, quantitative studies of the activities of selected compounds, and studies of the toxicity, absorption, excretion and fate of promising compounds in animals. In addition, studies are being conducted on the pharmacology and toxicology and mechanism of action of atabrine and certain other well-known antimalarials such as the cinchona alkaloids. Five laboratories are now under Government contract to conduct the pharmacological investigations and most of these are equipped to handle all phases of the subject. In addition, several laboratories are un-

der contract to investigate certain special phases of the general problems. Three other laboratories are cooperating very actively.

Most of these 6,000 compounds have been supplied by various pharmaceutical and chemical companies. Antimalarial activity of a greater or lesser degree has been found in many groups of chemical substances, hitherto not known to possess this activity. These leads have been explored as far as possible. A special panel is assessing the importance of the results so far obtained with a view to directing future efforts, and to submitting promising compounds for preliminary clinical tests in human malaria.

Among the groups of compounds possessing more or less antimalarial activity are the sulfonamides. Fortunately, in these compounds there is a background of related animal experimentation and clinical experience so that after a detailed pharmacological investigation of sulfamerazine it was possible to recommend it to the Army for field trial. The results so far have borne out predictions and encourage the belief that sulfamerazine will be valuable. In other cases so little is known of the comparative toxicity, absorption, excretion and fate of any member of a new group of compounds in animals and in man that elaborate clinical facilities are required to supplement the prerequisite pharmacological studies. Furthermore, the parasites used in the experimental animal infections are so different from those causing malaria in man that it is absolutely necessary to confirm the activity of a drug in human malaria before considering it worthwhile to explore synthetically the analogues of a given drug or series of drugs.

The Clinical Evaluation of Antimalarial Drugs: The facilities for the study of malaria as organized under the Panel for the Clinical Evaluation of Antimalarial Drugs includes the four hospital services. So far, these research facilities have fulfilled certain requirements for studies on the chemotherapy of induced malaria.

The emphasis of the work under the "Clinical Panel" has been on quantitative chemotherapy. Out of these studies have come precise evaluations of both known and new antimalarial drugs as determined under standardized conditions. There have been developed analytical methods for determining the whole blood and plasma concentrations and the data have been correlated with the therapeutic efficacy of atabrine, of the cinchona alkaloids, and of promising new antimalarials. As a result of the work on atabrine, more effective regimes of atabrine therapy and suppression have been evolved.

As a result of the increasing number of promising compounds flowing into the Office of the Survey of Antimalarial Drugs, the

demand for clinical investigations is overtaxing the present facilities, and arrangements are in progress for increasing these facilities.

The important link between the therapeutically included infection and the naturally occuring disease has been accomplished through the expansion of the present clinical facilities to include studies in Central and South America.

The malaria program as outlined will shortly be in full swing, and it is hoped that out of this large coordinated effort will come outstanding landmarks in the control, as well as the therapy, of malaria.

A PROPOSED PROGRAM TO PREVENT THE SPREAD OF MALARIA IN THE UNITED STATES FROM INFECTED INDIVIDUALS RETURNED FROM ABROAD

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It seems inevitable that the civilians of this country will experience some increase in malaria as the result of the return of many thousands of our soldiers from highly malarious areas of combat. The unavoidable relapses will doubtless infect existing anophelines, here and there, and will at least start limited outbreaks. There is also the possibility that local malaria problems will be augmented by the introduction of falciparum malaria into places where there was only vivax before, or by the bringing into endemic areas of new strains of vivax malaria to which the local people have not been partially immunized. Of course the less widespread malariae malaria with its reputation for frequent relapses may also play a part, though a very minor one. More remote, but real, is the added risk that the increased rapidity, volume, and irregularity of the international air travel involved in this war will bring in highly effective foreign anopheline vectors and thereby raise endemic malaria to a high epidemic level and make control more difficult, just as happened recently in Brazil when *Anopheles gambiae* was introduced under peace conditions from Africa (1).

The subject of this paper is, however, the control of the spread of malaria after it has actually been introduced into the United States. Previous speakers in this symposium have discussed the protection of troops against malaria in camps and in tropical battle zones, and also the measures taken to diminish the introduction of the malaria acquired in spite of the precautions and to destroy arriving exotic anopheline vectors by the disinsectizing of incoming airplanes.

In past wars returning infected troops brought malaria into communities where the disease was almost unknown and started outbreaks. Soldiers returning from the first World War took malaria from the Balkans and the Near East to many countries of Europe and as far as Australia. According to Hackett (2) malaria "dogged the footsteps of returning soldiers to their homes and infected countrysides whose inhabitants had never known the bitter taste of quinine. In Russia appeared the most terrible epidemic

of modern times, comparable only to those of North India, and in Italy a recrudescence occurred in areas long free from the infection, with the loss of decades of patient and hard-won progress. Secondary cases began to appear in England, while in such an unlikely place as Emden on the north German coast there was an epidemic of 5,000 cases."

For an example of what may happen when returning troops introduce an exotic species of malaria into an endemic area I can do no better than to draw on the experience of Craig (3) whom I shall quote: "In the State of Connecticut, in 1898, the only species of malarial plasmodium present in a certain region was *P. vivax* and benign tertian malaria was endemic in the locality for many years. After the end of the Spanish-American War, a company of the National Guard from this locality, the men of which had been on duty in a southern camp where infections with *P. falciparum* were numerous, returned to their homes. Within a few weeks cases of infection with this plasmodium began to appear, and before the end of autumn an epidemic of estivo-autumnal malaria had occurred, with a few fatal infections."

A typical example of a small outbreak of introduced vivax malaria in a northern town long free of the infection was described by Hoyt (4) in 1935. In Aurora, Ohio, no cases of malaria had been reported since 1920 when there suddenly appeared an outbreak of 37 cases of vivax malaria in a period of about two months. A recent introduction of malaria from Florida which probably gave origin to the outbreak was discovered. *Anopheles quadrimaculatus* was present. Ordinary measures of mosquito control, screening of patients, and specific therapy insured the prompt termination of the outbreak.

It seems improbable that accidents due to the introduction of falciparum malaria into northern regions in which it is not now existent and has not been prevalent in the past will be common, and undoubtedly the infection under such circumstances would soon disappear spontaneously. It is primarily the seriousness of this infection to the individual that compels attention. With vivax malaria the case is different. Its tendency to relapse repeatedly and after considerable intervals, and the high frequency with which it is likely to be present in returning troops makes it the greatest hazard. Over 90 per cent of the malarial relapses in troops already returned from overseas are of this type, according to Mc Coy (5). There are extensive non-malarious regions of the United States in which vivax malaria was prevalent under former conditions (6). In many communities in these regions effective an-

opheline vectors are still present in sufficient numbers to permit limited outbreaks if infective persons are introduced.

It is a matter of opinion whether the greater risk is in the non-malarious regions in which there are not many anophelines but enough to permit a few transmissions of malaria from an introduced case to a population which has lost all its immunity, or in the existing endemic areas where the anophelines are sufficiently numerous to keep malaria going and to step up the rate of infection when the number of infective persons is augmented. In the present endemic areas the increase in the number of infections will probably be greater than elsewhere and the outbreaks may be more lasting, but the disease is more likely to be promptly recognized and controlled.

With this picture of the problem in mind we can now proceed to consider the preventive measures which would seem to be necessary and practical. They fall naturally into two groups—those for the prevention of the introduction of infection into the community and those aimed at making the community less infectible through the suppression of dangerous anophelines. The plan here proposed is not regarded as complete or final, but it is hoped that it will stimulate discussion and advance the time of adequate concerted action.

Measures to minimize introduction of infection into the community.

1. *All individuals with malaria among returning military personnel should be treated until clinically free of the disease before discharge.* To do more would be impracticable, for it is not possible to determine which cases will relapse and there is no certain method of preventing relapse through treatment. Segregation of all the thousands who might possibly suffer relapses would be clearly unjustified, as would be also the prevention of their return to their homes. Prisoners of war having malaria should likewise receive treatment to a clinical cure before being sent where they could spread infection. Civilians returning from abroad with malaria should be adequately treated whenever this can be brought about.

2. *Special anopheline surveys and control should be undertaken to minimize the spread of malaria from places in which returning personnel with malaria are concentrated,* such as military hospitals and prison camps. On military reservations this is being done by the Army and Navy, and the hospitals are screened. In a surrounding zone the United States Public Health Service has undertaken to prevent the spread of malaria from returning military personnel and incoming prisoners by controlling anophelines just as it is protecting the armed forces from civilian malaria around training camps (5).

3. *The malaria patient on discharge from a military hospital should be notified in writing of the diagnosis and the species of plasmodium involved and should be instructed to consult a physician and show him the communication on the occasion of any subsequent illness within a year; and any reports requested by civilian health authorities should be supplied.* The statement for the physician is primarily for the benefit of the person involved, for there is great risk, especially in a non-malarious region, that a case of malaria will be unrecognized with resulting delay in treatment as well as in steps to protect the public health. In the case of falciparum malaria, which imitates many acute diseases, such loss of time may spell death for the patient. It is probably impracticable to require in addition that all cases in military personnel discharged after treatment for malaria should be reported as potential relapsing cases to the United States Public Health Service or the state boards of health concerned. There is doubt whether a flood of such reports would serve any useful purpose. Nevertheless it would seem advantageous if the military would supply reports of specified types of cases to the Public Health Service and to the health officers of states to which the discharged personnel are going, provided that a sound plan has been adopted there for acting on the information.

4. *Strong efforts should be made to educate physicians in the diagnosis and treatment of malaria and the fundamentals of prevention.* It is probable that many relapses will not be recognized and that numerous cases of falciparum malaria will be overlooked. Also treatment has become complicated for the physician by the substitution of totaquine and atabrine, with which he may not be familiar, for quinine. Through the health authorities he should receive in compact form at the earliest possible time an exposition of the essentials of diagnosis and treatment, with directions as to the use of atabrine and a statement regarding its safety and the symptoms of toxicity. For up-to-date information on this subject Circular Letter No. 153 from the Office of the Surgeon General of the Army may be consulted (7). Warnings against using soldiers from malarious theaters of war as blood donors would also be in order. Malaria programs before county medical societies and special articles in the regional medical journals would help. Such education should of course stress preventive measures, including the screening of the patient, prompt reporting and other cooperation with the health authorities.

5. *The medical technicians in governmental and private laboratories should be given special instruction and experience in the diagnosis of malaria through blood examination and in the recogni-*

tion of the species of plasmodium. They should be expert in the examination of thick films as well as thin. The state public health laboratory is probably the most appropriate agency for holding educational conferences for laboratory personnel, distributing pertinent reading matter, and providing specimen blood slides for practice in diagnosis and tests of efficiency.

Measures to make the community non-infectible.

1. *Extensive malaria and anopheline surveys, particularly the latter, must be made if malaria is not to take us by surprise.* It is better to locate the danger points by investigation than to have them revealed by the introduced infection. Fortunately most of the state health departments in areas in which malaria exists contain special organizations for the investigation and control of malaria, and most of the others have divisions or bureaus of epidemiology or communicable diseases which could take the responsibility for investigating the situation and supervising the control measures indicated. In 21 of the 48 States the state board of health has the responsibility for investigating suspected anopheline breeding areas and in one additional instance the responsibility rests on another state department, according to Mountin and Flook (8). Likewise the state health departments participate in drainage or anti-larval projects for malaria control in 13 states. Then there are among the 3070 counties of the United States 890 counties containing 47.1 per cent of the country's population, which have organized full-time health services (9) and should be able to carry out essential malaria surveys and control with the guidance and assistance of national and state health agencies. The United States Public Health Service could supply leadership in the program as a whole and give help where it is needed and requested. Through the surveys we need to find out the local densities of the anopheline species known to be efficient vectors, such as *Anopheles quadrimaculatus* and *Anopheles maculipennis* (*freeborni*). The conditions in malarious areas are already receiving considerable attention, but now the little-known potentially endemic areas have acquired added importance.

2. *Suppression of the breeding of dangerous anopheline species by the destruction of the larvae where their presence has been revealed by the surveys should be the main dependence for preventing the establishment and spread of the introduced infection.* A general tightening up of the existing well-known measures and their extension to wider areas is needed. The anti-anopheline activities would need to be so organized for this war period as to have exceptional possibilities for rapid mobilization for the control

of outbreaks in unexpected places. Trained personnel should be available and also an adequate store of the required larvicides.

3. *As supplementary measures for protection against infected anopheles the effective screening of houses and the spray-killing of adult mosquitoes should be instituted and popularized through propaganda.* These measures become of increasing importance as the density of dangerous anophelines rises and larva control is inadequate. The temporary distribution of drugs for suppressive treatment or for the treatment of malaria cases should not be necessary unless the situation should get quite out of hand and medical relief should become so urgent as to require attention from the health authorities while control measures are getting under way.

Need for a master plan and central guidance

The program outlined above is orthodox and reasonably complete, and it would doubtless bring improvement where fully followed, but it is far from satisfying. It lacks the boldness and simplicity of the sort of attack which might make a real difference in our whole malaria situation. Why not attempt seriously in selected areas to exterminate *Anopheles quadrimaculatus* or *Anopheles freeborni?* The success beyond all predictions of the major strategy in the extermination of *Anopheles gambiae* in Brazil (1) has fired the imagination of malariologists everywhere. The secret of the Brazilian success seems to lie in the thorough analysis of the problem, the selection of the one principal malaria-producing anopheline for attack, the emphasis on a single effective measure of control with constant check on the results, and the marshalling of adequate resources. The transmitting agent selected for attack was perhaps an anopheline especially vulnerable under the existing conditions but that this was so was not generally believed until local extermination had been achieved. The mainstay in control was the application of Paris green, although supplemental spray-killing of adults was utilized in the latter part of the campaign to hasten results.

In addition to the multiplicity of accepted measures stressed above for meeting the immediate emergency, I would urge that a master plan be evolved and adequately financed as soon as the necessary surveys and analysis of results can be completed, and that an all-out attack be made on our two most effective vector species in areas in which they would be especially vulnerable and might conceivably be locally exterminated. The research now being devoted to discovering and testing more effective larvicides should add to the chances of success. For central leadership we could look to the United States Public Health Services if it would set up a suitable agency, perhaps developed from its existing Office of Malaria

Control in War Areas. It is high time that the pessimism regarding complete control of dangerous anophelines in the United States should give way unless placed on a solid basis of fact established by experiment.

In the first stage of the master plan it may be expedient to limit the attempt to exterminate the anopheline species to one or more areas selected on the basis of isolation and favorable conditions, and in other chosen places to drive directly at the extermination of malaria itself through less complete suppression of anophelines. The degree and rapidity of success in such experiments would determine the final program for ridding this country of malaria.

A concerted scientific drive on the most dangerous anophelines would be the most effective single item in a program to prevent the spread of malaria from introduced infected individuals. If organized as the commencement of a well-planned, centrally-directed war to exterminate malaria and the most dangerous anophelines, it would insure maximum benefits for the future.

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A PROGRAM FOR THE ERADICATION OF MALARIA FROM CONTINENTAL UNITED STATES.*

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My proposal, in brief, is that malaria in continental United States has reached such a low ebb when a relatively small amount of concentrated effort directed at the foci where conditions are favorable for transmission, coupled with a flexible program designed to suppress localized outbreaks elsewhere, will result in the eradication of that disease from this country.

Two related subjects have occupied the attention of the Malaria Control Staff of the United States Public Health Service to the point where they may be assuming the status of obsessions. Briefly, they may be expressed in the form of questions, (1) "Can malaria be eradicated from continental United States?" and, (2) "How should the problem of the malaria carriers among returning troops be met?"

Dr. L. L. Williams, Jr., proposed an answer to the second by answering the first in the affirmative. The proposal to eradicate malaria is wholly his. In fact, those of us who have become disciples did so through the process of being, at first, "very doubting Thomases"; but the facts are sound and once convinced we have become enthusiasts even when not under the spell of Dr. Williams' persuasive personality.

The crux of the situation is the soundness of the belief that in a large portion of the malarious areas of the United States malarial infections are not perpetuating themselves. A blood smear survey of 129,000 school children in 1932 gave a positive rate of 5.8 per cent. This was a sufficiently high rate to allow for an increase in the rate to a peak in 1934-35. However, from that time on there has been a steady decrease. A survey of 109,000 school children in 1942, sampling the same general area but carried on in the vicinity of war areas, has shown a positive rate of only 0.21 per cent—a difference of one in twenty contrasted with one in 500. Since 1934-35 the morbidity rates have fallen in an unbroken recession. These rates, which are often misleading, are substantiated, however, by the mortality rates for 15 southeastern states which have shown an uninterrupted decrease from 4,345 deaths in 1935 to 808 in 1942. In the five year period 1935-39 there were 96 counties in 12 southern states with average annual

malaria death rates in excess of 30 per hundred thousand. During 1938-42 there were only fourteen such counties in seven states. And, above all, the cyclic upswing which previous experience had taught us to expect in 1941-42 failed to materialize; instead the rates continued to decrease.

I realize that too many investigators have had their scientific reputation impaired by attempting to prophecy how many mosquito bites were necessary to produce a malarial infection. I am not going to attempt this but I will make a philosophical statement that can't be argued: Along the line of recession of the malaria rate a point will be reached where either human carriers or anopheline vectors or both become so scarce that the disease cannot perpetuate itself from sheer mathematical odds. It is well known that endemic malaria disappears from an area long before potent anopheline vectors do; in fact, it may even in the presence of relatively large numbers of them. I hasten to refresh your memory on that point before our proposal of eradication is condemned by those who visualize the vast expanse of anopheline breeding waters and consider eradication of malaria synonymous with the eradication of anophelines. In many sections of this country that are now classified as endemic areas of malaria all that is needed to start malaria toward extinction is a small reduction in anopheline densities or the institution of adequate protection against their bites.

Even within the memory of the older members of the National Malaria society malaria has receded from the entire humid United States excepting only the upper portion of the northern tier of states and the crest of the Alleghanies to an area of the southeast bounded roughly by the latitude of Washington, D. C. and the longitude of San Antonio, Texas. This latter area is being maligned as the so-called malarious belt. Within this region are many large sections that today have already passed through the same stages as southern New England, the central Atlantic Coast, the Ohio Valley, the Central Valley of California and the Williamette Valley of Oregon. All of these sections have passed progressively through periods of high endemicity approaching hyperendemicity to hypoendemicity. This hypoendemicity is characterized by a condition of affairs where to all intents and purposes malaria has disappeared but where its reappearance is enacted from time to time in the form of small explosive and generally self-limiting epidemics whenever the right anophelines and a supply of imported carriers get together in sufficient numbers under propitious circumstances.

I think you'll agree with me that the textbook theorem "Anopheles + Human Malaria Carriers=Malaria", is an extremely mis-

leading statement. Potent anopheline vectors exist in every state in the Union. With the present dislocation of domestic populations, numbers of human carriers have been introduced into all parts of the country yet we know of only one explosive epidemic of malaria, and that a small one, in the Nation this year (Johnson City, Illinois).

The prevalence of malaria and its degree of endemicity is a meticulously balanced relationship between mosquito vectors, human carriers and the ecological conditions under which they operate. Provided both vectors and human carriers are present in an ecological setting at least potentially possible for transmission, an overwhelming number of either would counteract a paucity of the other, but the long range controlling factor is the ecological setting. These ecological factors may be related to the natural climatic conditions or they may be man made.

Low temperatures and low humidities, for instance, are inimical to easy transmission; thus even with high densities of vectors and plenty of carriers in areas having these characteristics a much smaller amount of protective work might tip the balance against transmission than would be required in climates more favorable to transmission. This explains undoubtedly, the recession of malaria from certain northern areas and from the irrigated sections of the semi-arid west following a minimum of effort.

The ecological hurdles set up to embarass easy transmission that man has instituted by agricultural drainage, the construction of better housing, the introduction of screening and—most important of all during the last twenty years—the advent of household insect sprays as housekeeping necessities, have done more to decrease the incidence of malaria than all the conscious efforts that have been directed along this line.

A safe and reliable drug or vaccine which will prevent malaria is the ultimate desideratum in the control of malaria. To date, however, the best preparations that are available influence only the clinical symptoms and death rate but have little, if any, effect on the infection rate. Control of anopheline breeding and protection from anopheline biting has repeatedly tipped the balance between transmission and non-transmission to the end that malaria has disappeared from a commuity, an area, or even an entire section of the country.

However, from 1938 to 1942 in some forty two counties in the South transmission of malaria was sufficiently easy and frequent to produce an annual average mortality rate of over 20 per 100,000. Some of these counties already, by virtue of the estab-

lishment of war industries, have a portion of their area under adequate mosquito control.

Even in the so-called malarious counties the sources of infection are localized. Dr. Williams' plan proposes that these foci and perhaps others should receive concentrated anti-malarial attention centering on anti-anopheline measures which might include screening and interior spraying if necessary. In addition, mobile units would be available to produce early extinction of explosive epidemics that developed outside the recognized endemic areas before they establish new foci. Some of these forty odd counties would require more attention than others but an average estimated expenditure of $125,000 per county per year may be taken to represent an amount that could be directed efficiently.

The number of years required to complete the job of eradication would depend wholly on the character of the local control conditions involved and the attitude and helpfulness of the population concerned. Three years would be an adequate trial period. By that time the trend of morbidity and mortality experience should indicate the progress, success or ineffectiveness of the program and dictate the course of further action.

The Public Health Service proposes to undertake, in cooperation with the States, a portion of this plan. When and if the manpower situation relaxes, it is possible that we may receive authority to proceed with the States on the entire plan. Its active prosecution would do a great deal, if indeed, it were not the complete answer as to what procedures should be adopted with relation to returning members of the armed forces who are going to be subject for many months to relapses of malaria acquired overseas. The question which remains uppermost in my mind is whether we are being true to ourselves and our profession in accepting, without at least presenting the facts, the dictum that a concentrated attack on the strongholds of malaria should await a post war period, when manpower stringencies are less acute. If the malaria rate remains static or continues to recede, eradicative measures will furnish a valuable post-war activity and little ground will be lost by delay. If, however, with the impetus of returning malaria carriers, an upswing of malariarates and an extension of foci take place we will have been negligent in our immediate duty and will have failed to grasp an opportunity which might not occur again for a generation.

The United States Public Health Service expects to continue, for the duration of hostilities, its malaria control program in war areas. In addition it proposes to inaugurate mobile units for the control of malaria in the vicinity of any areas where concentrations

of malaria carriers are expected such as, general hospitals, prisoner-of-war camps, and debarkation centers. Within the limits of our resources these units will be available for the suppression of any outbreaks of malaria outside the war areas that are incident to returning troops. This limited program falls far short of that which is required for total eradication.

In addition, I would earnestly advocate, and here I seek the advice of the States, an extension of our combined efforts to the root of the malaria problem. With the fullest cooperation of Federal, State and local Agencies, including a fair financial contribution on the part of each, a concerted attack can be made on the remaining foci where the disease is more than holding its own. Thus the balance may be tipped in favor of humanity and malaria in continental United States may become a matter of historic interest only.

Without the wholehearted approval and cooperation of all agencies concerned this proposal would be absolutely futile. If you think well of it I ask that you give us your best thought in effective planning and if you don't think well of it at the moment —well, I ask that you think about it some more but not too long.